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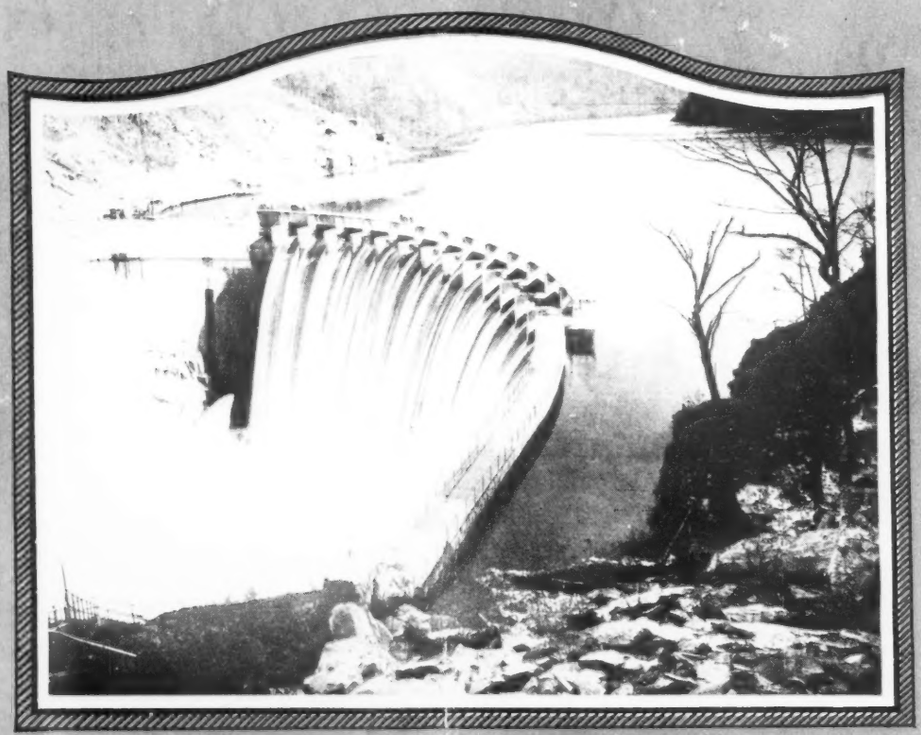

CATALOOCHEE DAM IN NORTH CAROLINA IMPOUNDS WATER FROM PIGEON RIVER TO DRIVE BIG TURBINES MORE THAN SIX MILES DISTANT

Pigeon River Now Turning Great Water Wheels
S. G. Roberts

Stoneyhurst Quarries Produce Beautiful Stone
J. S. Meehan

Pennsylvania Railroad Building New Terminal
R. G. Skerrett

Old Bridge Strengthened for Modern Service
C. H. Vivian

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BIG BALL BEARINGS ?
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As It Seems To Us

IMMUNITY TO COMMON COLDS

COMMON colds cost American workers a loss in wages of $2,000,000,000 annually, so it is authoritatively estimated. Search has been underway for some time in this country for the primary cause of this prevalent source of physical disturbance, and the good news has just come from Baltimore that a microscopic organism has been isolated and convincingly identified as the source of our most common ailment.

The technicist of the Maryland Medical School responsible for the discovery has said: "We are certain that the micrococcus in question is the one we have been looking for, and that persons can be immunized against its effects.....We have proved both points to our satisfaction by experiments with animals and with humans."

We sincerely hope the doctor is right.

IS HE A METHUSELAH IN THE MAKING

ZARO Agha—present-day runner-up for METHUSELAH and SOLOMON—is visiting the United States, thanks to the munificence of a wealthy compatriot, an Istambul exporter. ZARO AGHA is said to be 158 years old, and still vigorous. It occurs to us that he is probably geared differently from the vast majority of us. At this time we lack details about how he has spent his unusually protracted existence, which is more than twice the lengthy span of the three score and ten years mentioned in the Bible.

While ZARO AGHA is reported to have subscribed to those tenets of Mohammedanism that call for abstinence in certain particulars, it would seem that this very aged Turk has gone the limit in his matrimonial alliances; and it is fair to assume that the wisdom he has garnered in this department of human relations puts him in that class headed by the much married SOLOMON. Manifestly, matrimony has not palled upon him. The Turk is to make the rounds of certain of our universities, medical colleges, and scientific societies, so, it is said, that the inquiring gentry of those institutions may discover, if possible, the secret of ZARO's longevity.

We don't want to go on record as being unreasonably skeptical, but we do wonder whether or not there has not been some guesswork about the date of his birth. If his years be as announced, then is not his great age merely evidence of the remote kinship between the animal and the vegetable kingdoms? And we ask: "Has he ever done anything more than just live?" Whatever may be at the bottom of ZARO's vital persistence, we don't count much upon his coming to change our habits and our ways of doing things. A shorter life and a merrier one would probably be preferred by most of us.

MACHINERY ON THE FARM

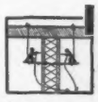
WE are all familiar with the childhood tale running—"This is the cat that killed the rat that ate the malt that lay in the house that Jack built." Upon mature reflection we see that the line is merely one more way of bringing home to the youthful mind a chain of interrelated factors. Similarly, the Bureau of Labor Statistics of the United States Department of Labor has recently revealed the economic effects of substituting machinery for draft animals on the farm. The consequences of the change are much more radical than most of us are aware, and illustrate that the upsetting of the accustomed order of things is not always a sure way to bring about unalloyed betterment.

Considered casually, the use of machinery in place of draft animals would seem to be a gain in operating efficiency, making it possible to do more of some kinds of work in a given time and with fewer hands—the machine not requiring the expenditure of motive fuel when idle. Conversely, draft animals must be fed in their off hours, they must be properly housed, and a good deal of care is required to keep them in health and in fit working condition. Furthermore, their useful life is uncertain. Even so, the mule, the horse, and the ox make other returns than those of work done. They give back to the soil a valuable measure of plant food—compensating by just so much for their use of what the land has produced upon which they toil.

It seems that the displacement of draft animals by machinery has brought in its train a grain surplus and a huge reduction in the outlet for farm products. In other words, the curtailment of the normal increase in horses and mules through the substitution of automobiles, trucks, and tractors has, so it is reported, cut down the acreage needed for the production and maintenance of animal power from 107,162,500 to 52,905,000 acres. Manifestly, the preparation of the soil, the sowing of seed, and the harvesting of animal foodstuffs on 54,257,500 acres annually must call for the services of many persons and bring in its train substantial rewards.

While the contending advocates of animal power and machine power are not in accord on a number of points, it is recognized that it is easier to care for a tractor than it is to look after a team of eight or ten horses. On the other hand, experience is said to have disclosed that the work essential to producing grain can be done more efficiently and at a lower cost with draft animals. What is the general public to believe?

NO NEED FOR US TO WORRY ABOUT BUSINESS



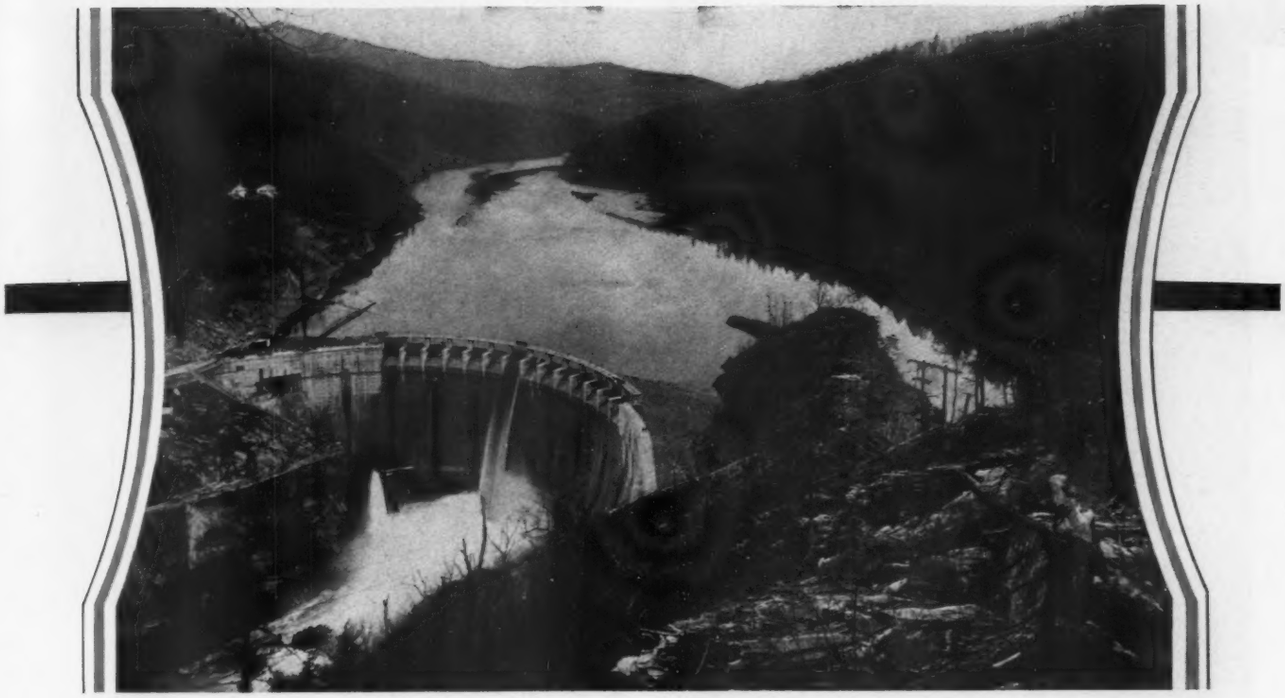
IT is a fact that any undertaking in the full tide of prosperity develops operative shortcomings, lost motion, and numerous other kindred defects; and to restore it to a healthy state things must be done to reëstablish normal conditions and to make it fit to hold its own in the competitive race of sound business. According to a recent pronouncement by The National City Bank of New York, the United States is now passing through just such a process; and when that readjustment is completed business in this country will be on a far sounder basis than it was twelve months ago. Let us quote:

"Precisely how long this period of readjustment and reorganization will take in any given instance depends a great deal on how much resistance is accorded to the forces working to reëstablish an equilibrium. Since all business in the last analysis consists of an exchange of products and services, it follows that any group seeking special advantages for itself in defiance of economic law, by holding out against the trend, constitutes a disturbing element which tends to retard the recovery of business as a whole. The demonstration has been made repeatedly that efforts of this sort fail of their purpose, usually with magnified losses to all concerned, yet such is the reluctance of mankind to be guided by experience that there are always some ready to make the attempt anew.

"Nowhere is this realization of the joint responsibility for maintaining stability in industry more imperative than in the relations between labor and capital. There is an obligation upon both to have regard for the public welfare and to work in good faith and willing coöperation to secure the largest and best results. Moreover, this policy involves no sacrifice to either party. Labor has a larger interest in actual wages than in nominal wage rates. The rise of the standard of living always has been dependent upon the increasing efficiency of the industrial organization as a whole."

Manifestly, each and all of us can contribute to business betterment by doing our individual parts in speeding up readjustment and the return to that condition of business and industrial soundness upon which prosperity inevitably must rest. Deeds not theories are what will count most in hastening us toward our goal—in short, well-directed work is the remedy.

Power house and Pigeon River Valley seen from a hilltop on the Hartford side of the river.



Pigeon River Now Turning Water Wheels Of Great Hydro-Electric Plant

This Recently Completed Undertaking Supplies a Large Block of Current to Homes and Industries in North Carolina and Tennessee

By S. G. ROBERTS

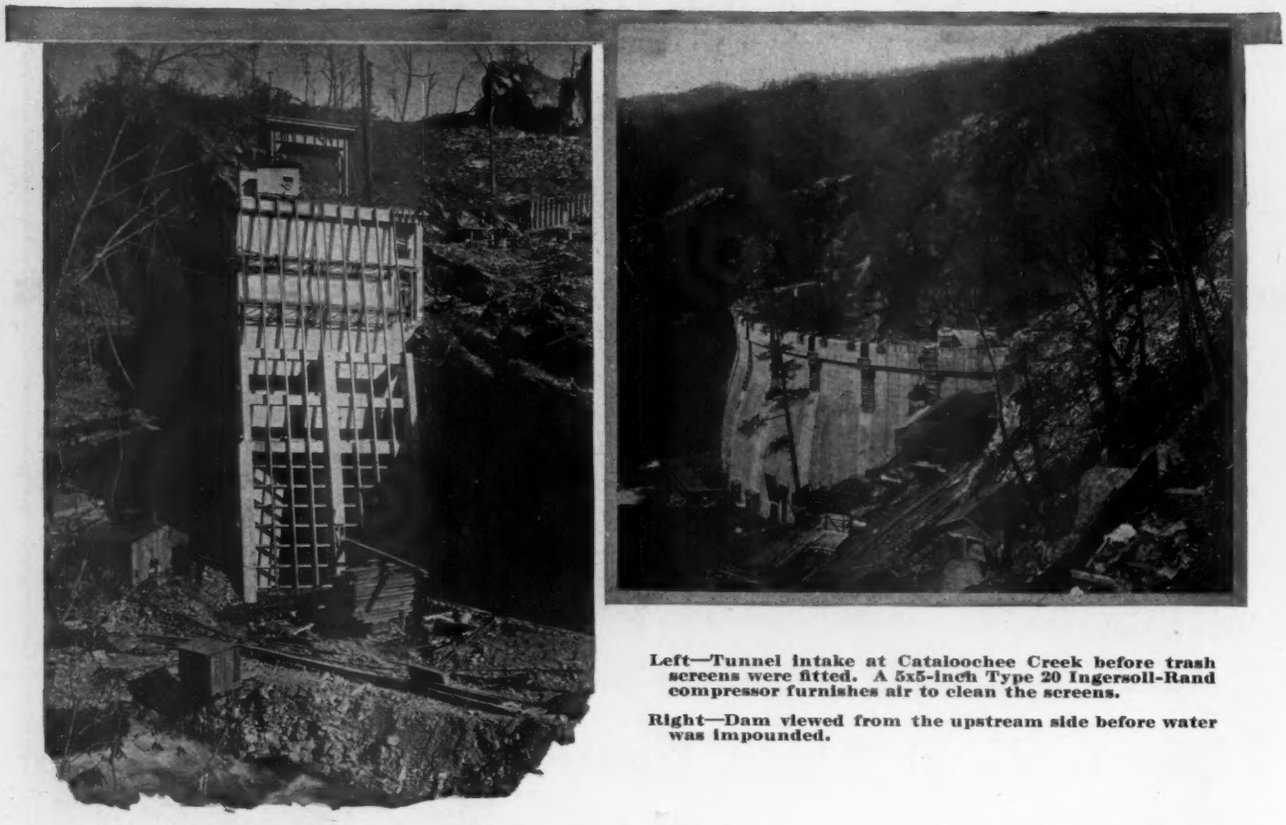
HIDDEN deep in the heart of the Great Smoky Mountains—miles and miles from any of the much traveled highways—there is a big hydro-electric plant that hums significantly as it sends current broadcast to produce light and to drive motors in all sorts of present-day services. We speak of the Waterville Station of the Carolina Power & Light Company—recently put in operation—that utilizes motive force garnered from the Pigeon River, force that had previously gone to waste for untold ages.

The Waterville Station lies in North Carolina and just over the boundary between that State and Tennessee; and it is at the point where Big Creek empties into the Pigeon River. The site was selected after engineers had explored the river for the dual purpose of determining where to rear a great dam and where the power house should be put which would utilize the impounded waters and the natural head of the stream between the two man-made structures. The location chosen for the dam was immediately below the point where Cataloochee Creek discharges into the Pigeon River—that is, about 12½ miles upstream from the power-house site.

Between Big Creek and Cataloochee Creek the river traces a tortuous course that is virtually a great sinuous arc—the valley being a steep one that frequently has the form of a rock-ribbed gorge. The engineers have linked the two ends of this arc with a chord made up of a series of tunnels. These tunnels have been driven straight through the solid rock of the intervening mountains save where the line crosses the bottom of the valley through which Mount Sterling Creek flows on its way to the Pigeon River. From end to end, the tunnels have a combined length of 32,700 feet, broadly divided into an upper and a lower tunnel level—the interval between them being 550 feet and linked by a vertical shaft. With the lake above the dam filled, the static head between the lake and the tail-water at the power house is 861 feet.

Except at certain points the tunnels are of horseshoe section, having a height, within the concrete lining, of 14 feet 8½ inches and a maximum width of 12 feet 6 inches. At the intake, at the discharge, and at the connecting points, the section is circular—being generally 14 feet in diameter. Just before the lower-level tunnel issues from the mountain back of the power house, the section changes to a circular one and then expands into an elliptical chamber that broadens, within an interval of 30 feet, from 14 feet to 22 feet. From this Y-chamber diverge, like fingers, three tunnels, each 8 feet in circular section and 650 feet long. These are the penstock tunnels that feed into the steel penstocks that are designed to carry the water to the turbines in the power house. At the present time but two of these generating units are installed—the third unit will probably be ready for service before the summer is over. To be more specific, each generator is driven by a 49,000-hp. turbine; and the total capacity of the plant will be, with the third unit in place, 108,000 kw. The dynamos produce current of 13,800 volts; and this is stepped up by transformers to 110,000 volts before it is sent over the line to distant distributing stations.

For the sake of a better understanding of the development, let us trace the tunnels from the dam site northward to the power house. Nature favored the engineers by turning the course of Cataloochee Creek, at its outlet, sharply upstream against the course of Pigeon River. This is due to a towering and narrow tongue of solid rock—the tongue serving to shelter the tunnel intake on one side and to provide a perfect lodgment for one end of the dam on the other side of this promontory. From the intake, the upper-level tunnel runs on a straight line through the backbone of the superposed range for 16,000 feet, coming out then in the bed of Mount Sterling Creek. From Mount Sterling Creek northward, the tunnel continues for a distance of 5,000 feet—the two portals in the



Left—Tunnel intake at Cataloochee Creek before trash screens were fitted. A 5x5-inch Type 20 Ingersoll-Rand compressor furnishes air to clean the screens.

Right—Dam viewed from the upstream side before water was impounded.

bed of Mount Sterling Creek being joined by a great steel pipe 300 feet long and 14 feet inside diameter.

At its northern end the 50,00-foot tunnel meets the 650-foot shaft sunk from the hill-top at that point. This is what is known as Gap Shaft, and this shaft is provided with a vent that permits the escape of air which would otherwise be pocketed at that intersection. Northward from the Gap Shaft, the lower-level tunnel descends on a varying grade until it meets the bottom of another 650-foot shaft that is now crowned by a surmounting surge tank 193 feet in height and 42 feet in diameter. The top of the surge tank is somewhat higher than the high-water level at the dam. The purpose of the tank is to serve as a relief valve that prevents destructive water-hammer effect when surging is set up in the tunnels by the opening or the closing abruptly of any of the penstock valves that control the flow of water to the turbines. From the Surge Tank Shaft onward to the triple outlet, the tunnel system is essentially as already described. In driving the tunnels and in sinking the shafts it was necessary to excavate a total of 244,000 cubic yards of rock.

To impound the waters of the Pigeon River so as to produce a static head of 861 feet at the tailrace of the power house, the Carolina Power & Light Company had to rear a dam 187 feet high from the rocky river bed to the tops of the spillway gates. These gates, when closed, raise the water level in the lake 10 feet above that of the spillway. The dam is of concrete and of the variable-radius arch type; and from side to side, where it is anchored to the rocky flanks of the valley, the curved crest of the dam measures 870 feet. The lake so formed has an area of 360 acres and backs the water upstream for a distance of 5½ miles. While the reservoir is narrow, its total capacity of 22,000 acre-feet is due to the depth of the gorge. So much for the broad features of the project: now for some details of the way the work was done.

With the sites for the power house and the dam predetermined for them, the subcontractors—Parker-Graham-Sexton, Inc., and the Pigeon River Tunnel Company—had to devise ways and means to get supplies, materials, and machinery to the several points where operating bases were to be established. At that time, Waterville was an inconspicuous station on the Tennessee & North Carolina Railway which runs between Newport, Tenn., and Crestmont, N. C., and follows the river

Left—Mount Sterling Creek was diverted through an overhead flume while the tunnel portals were driven in the stream bed. Right—Narrow-gage railway built between Pigeon River and the tunnel camp on Mount Sterling Creek.

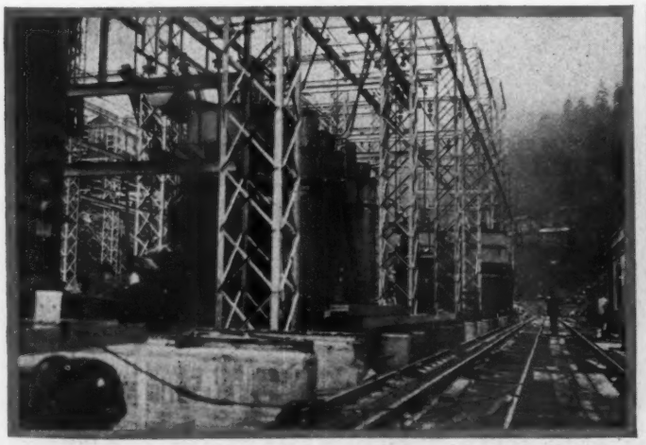
Left—Cableway across Pigeon River at the mouth of Mount Sterling Creek.

Right—Part of the 1,900-foot incline railway that has carried supplies and men from Waterville up to the Surge Tank Shaft.

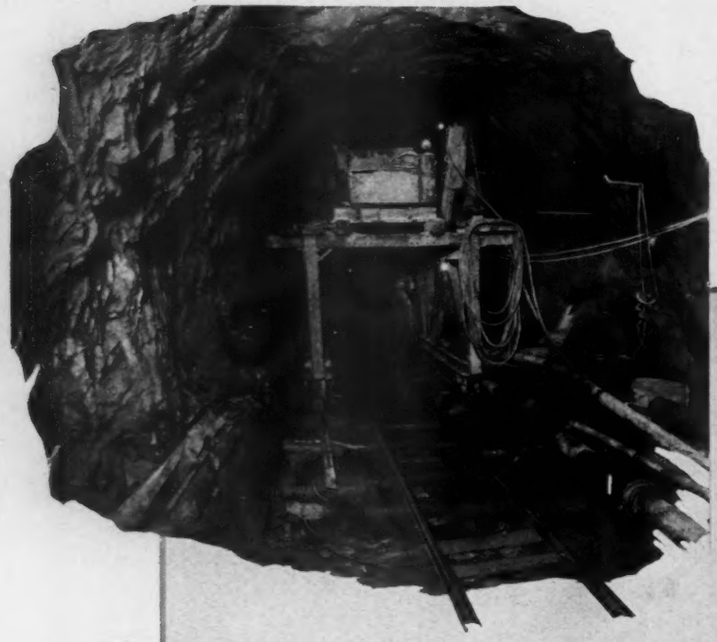
from Newport to Waterville, where it turns into the mountains and parallels the course of Big Creek. Newport is on the Southern Railroad and 21 miles downstream from Waterville, so it was comparatively easy to move freight and workers from Newport to Waterville; but the far more difficult problem was to transport men, supplies, and machinery to the dam site located in an utterly isolated region 12½ miles higher up the Pigeon River, and also to get equipment and men to the camp on Mount Sterling Creek where two of the tunnel portals were to be situated.

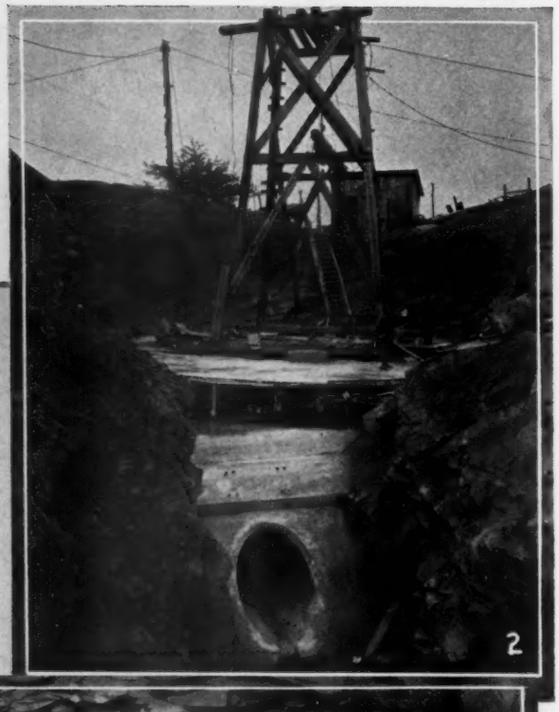
Hartford, Tenn., on the opposite bank of the Pigeon River and four miles below Waterville, boasts mills where logs cut on the mountainsides farther upstream are sawed into marketable lumber. To supply these mills a narrow-gage railroad runs along the north shore of the river for seven miles above Waterville, and then turns away from the stream and back into the timberlands. This road traces its way along a shelf cut in the steep slope of that flank of the river valley; and it was possible for the Phoenix Utility Company to get a right of way over the existing tracks as far as they followed the river course. But from that point up to the site of the dam—a distance of 5½ miles, the company had to build a railway spur, and to do this it was necessary to drill and to blast the mountainside and to bridge a number of steep gulches. The construction of that line was an engineering achievement in itself; and when finished it served as the main transportation artery between the dam and Waterville. It was not possible, however, for the contractors to await the completion of that narrow-gage line before starting work at the dam site and on the tunnel that was to link the intake at Cataloochee Creek with the portal at Mount Sterling Creek, 16,000 feet distant. To save time, certain indispensable equipment needed in preliminary operations was shipped to Lake Junaluska, N. C., a station on the Southern Railway, whence that freight was hauled by tractor over questionable roads for something like twenty miles. There were times when the outlook was desperate, but the tractor was able to make the grades and finally to reach its objective by main force in the heart of the towering hills.

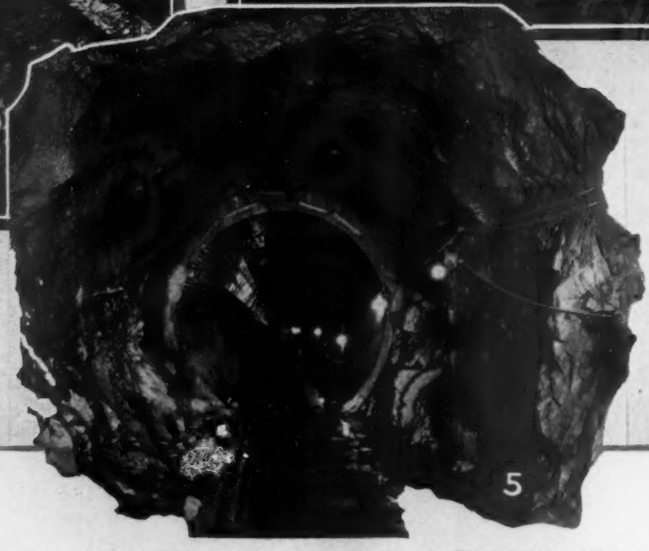
Waterville is set at the foot of a mountain that rises abruptly to a height of 2,100 feet. The sites of the Surge Tank Shaft, the Gap Shaft, and Mount Sterling Creek crossing were made accessible by constructing an in-



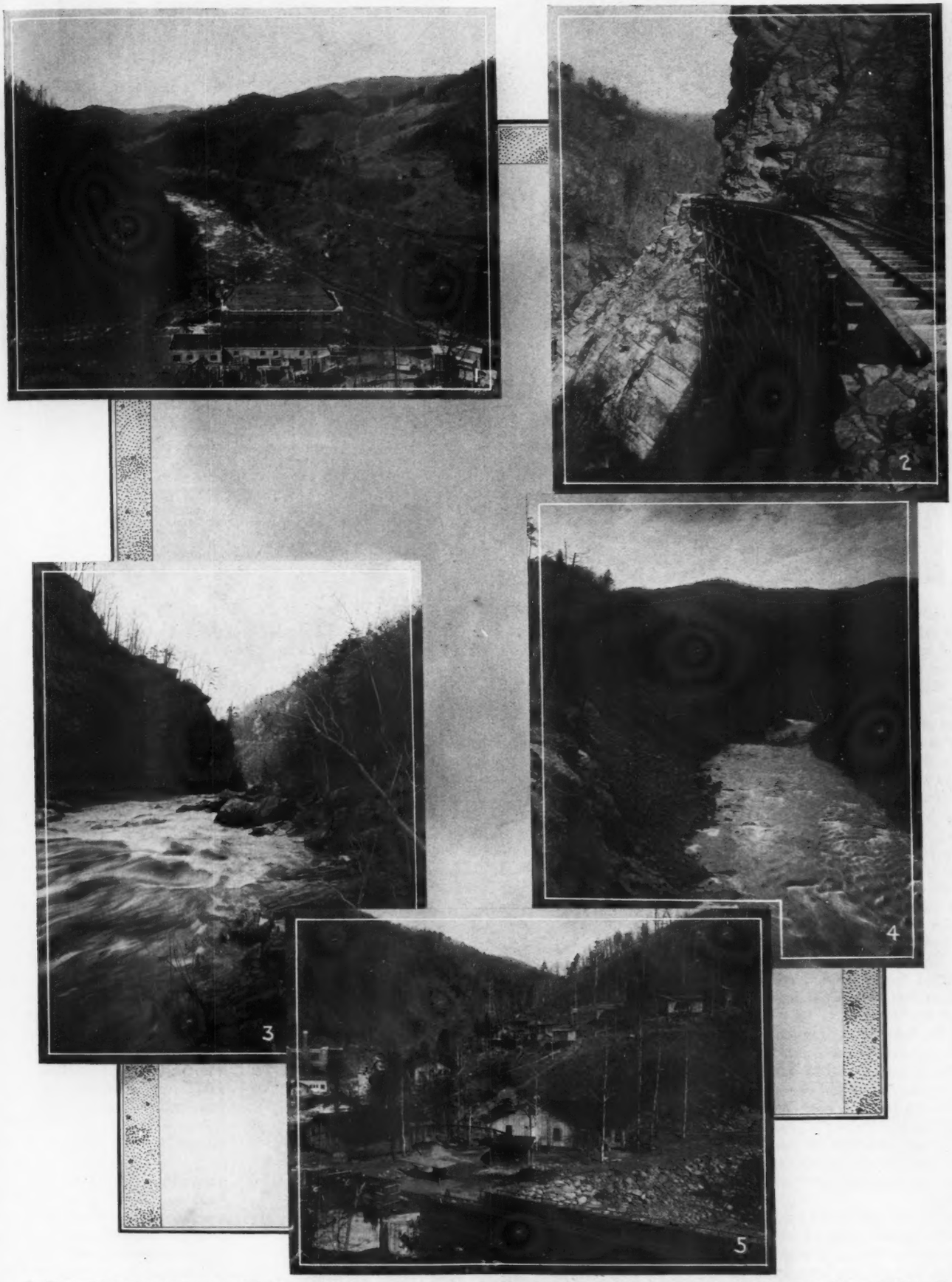
Left—Switchyard at rear of the Waterville power house. Right—Ford cars, with flanged wheels, performed passenger service between the Waterville camp and the camp at Cataloochee Creek 12½ miles farther upstream.







1—Pneumatic concrete-placing machine at work lining a tunnel section. 2—Foundation of the surge tank, with outlet for overflow water. 3—Pressure tunnel with concrete side walls and arch in place. 4—Elliptical chamber from which three 8-foot penstock tunnels diverge toward the power house. 5—A lined circular tunnel section near Mount Sterling Creek portal.



1—Power house and river viewed from below the surge tank. 2—Narrow-gage railroad crossing a trestle over a deep gulch. 3—A tumultuous section of the Pigeon River. 4—Where Pigeon River threads its way among somber ridges between Waterville and the dam. 5—Contractors' camps on mountainside in Big Creek Valley back of the power house.

Oval—Ingersoll-Rand air-driven sharpener and oil furnace in one of the several similarly equipped blacksmith shops on the job. Right—Pneumatic pedestal grinder and an array of drill steels of different lengths such as were used in driving the tunnel sections. Left—Air-operated Cameron pumps were used in unwatering the tunnel sections. Water, however, gave but little trouble.

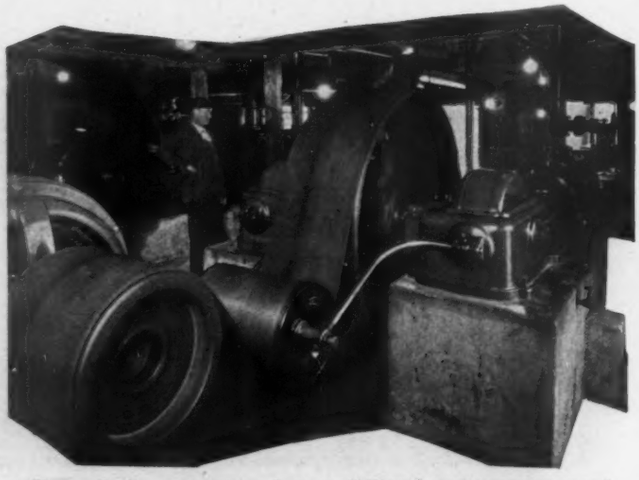
cline railway from Waterville up to the top of the ridge behind the camp. From the end of that railway, tractors were used to pull the supplies over a trail along the ridge to the Gap Shaft and to Mount Sterling Creek crossing. Later, a spectacular cableway, with a span of 1,700 feet, was built across Pigeon River at the mouth of Mount Sterling Creek. This aerial route connected with the logging railway running between Waterville and the dam site, and facilitated the quick transport of men and equipment. Another narrow-gage railway was constructed between the mouth of Mount Sterling Creek and the camp at the tunnel crossing two miles up from the river.

Work on the Cataloochee-Mount Sterling Creek tunnel was started in June of 1927 from opposite portals, and the headings were holed through on June 25, 1929. The tunnel section extending northward from Mount Sterling Creek to the Gap Shaft was attacked by headings at each end, and the lower-level tunnel was driven respectively northward and southward from a heading at Gap Shaft and another at the outlet adjacent to the power house. We are indebted to Mr. Robert E. Parker, general superintendent for the subcontractors, for the following particulars regarding the tunnel-driving operations.

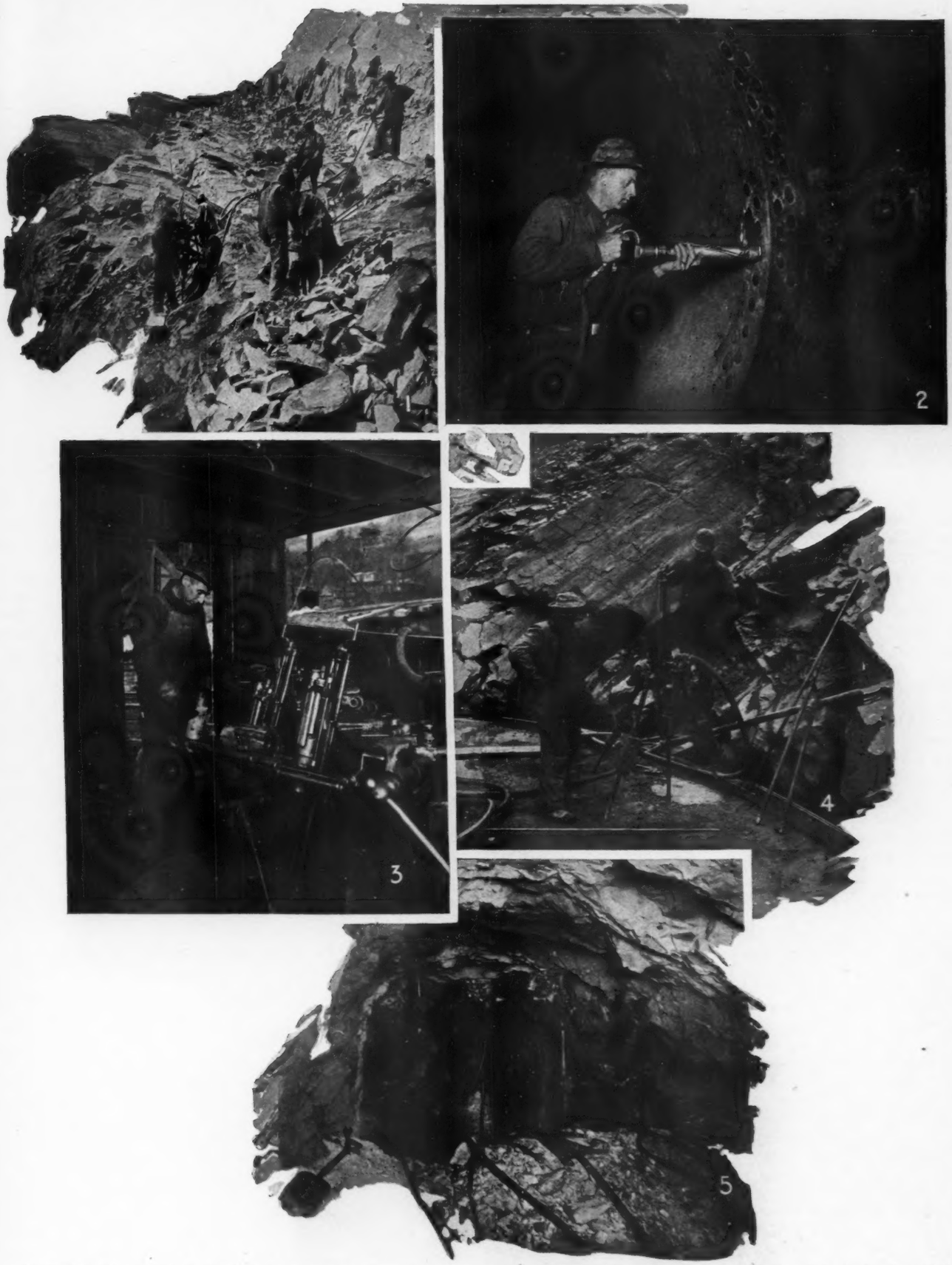
The tunnels were driven by the bench-and-heading method and, as far as possible, the bench was kept within 8 feet of the heading, although this varied somewhat at times. The headings and the benches were drilled with Ingersoll-Rand R-72 drifters—mounted on crossbars at the benches and on columns at the headings; and all holes were horizontal. The men worked in two 10-hour shifts each 24 hours; two rounds were drilled a day; and an average of 9 feet was pulled at each round. A standard V-cut was used in the headings; and the number of holes in a round for a heading and a bench varied with the character of the rock encountered. The deepest holes were drilled with steels 13 feet long.

In some sections of the tunnels the rock is what is termed arkose and exceptionally hard. Arkose is composed of quartz and feldspar. The mucking was done with electrically driven Myers-Whaley machines; and the muck was drawn from the headings in 60-cubic-foot Koppel steel cars—the trains being pulled by Whitcomb-Mancha electric locomotives. Fresh air was delivered to within 75 feet of each heading through 6-inch steel tubing; and Roots blowers discharged the air at a pressure of 10½ pounds. The tunnels were relatively dry—the maximum amount of water handled being about 300 gallons a minute at the Waterville portal. All pumping was done by pneumatically driven Cameron pumps. The two 650-foot shafts were sunk with Ingersoll-Rand No. 248 drifters and DCR-23 "Jackhamers". The "Jackhamers" were also used for block-holing and trimming where necessary.

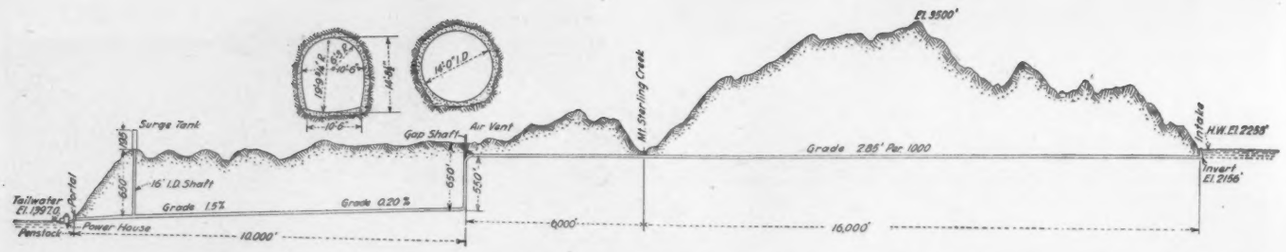
The tunnels and the shafts are lined with concrete throughout; and in the tunnels the lining varies in thickness from a minimum of 4 inches to an occasional maximum of 4 feet, depending upon the way the rock broke—the average thickness being from 16 to 18 inches. This work was done as the headings advanced, and the concreting followed about 1,000 feet rearward. The lining was placed pneumatically with Ransome machines, and Blaw-Knox collapsible steel forms were utilized. Considerable grouting was done in the tunnels after they were lined to fill voids formed in the concrete arch; and before lining the different tunnel sections the rock was invariably cleaned with jets of compressed air to insure the closest possible bond. A 50-foot form was shot every three days when the tun-



Two of the numerous Ingersoll-Rand compressors used on the job. The combined output was about 6,000 cubic feet of air per minute.



1—Drilling down-holes with N-72 sinkers in the quarry near the dam. 2—Driving 1⅛-inch hot flush-head rivets in one of the steel penstocks with a No. 90 riveting hammer. 3—Drill service shop at the Waterville camp of Parker-Graham-Sexton, Inc. 4—Drilling anchor bolt holes in concrete foundation of the surge tank with R-72 drifters. 5—Heading in pressure tunnel near Cataloochee Creek, using four R-72 drifters mounted on columns.



Longitudinal section showing general disposition and principal features of the Waterville hydro-electric plant. Small drawings are of horseshoe and circular tunnel cross sections.

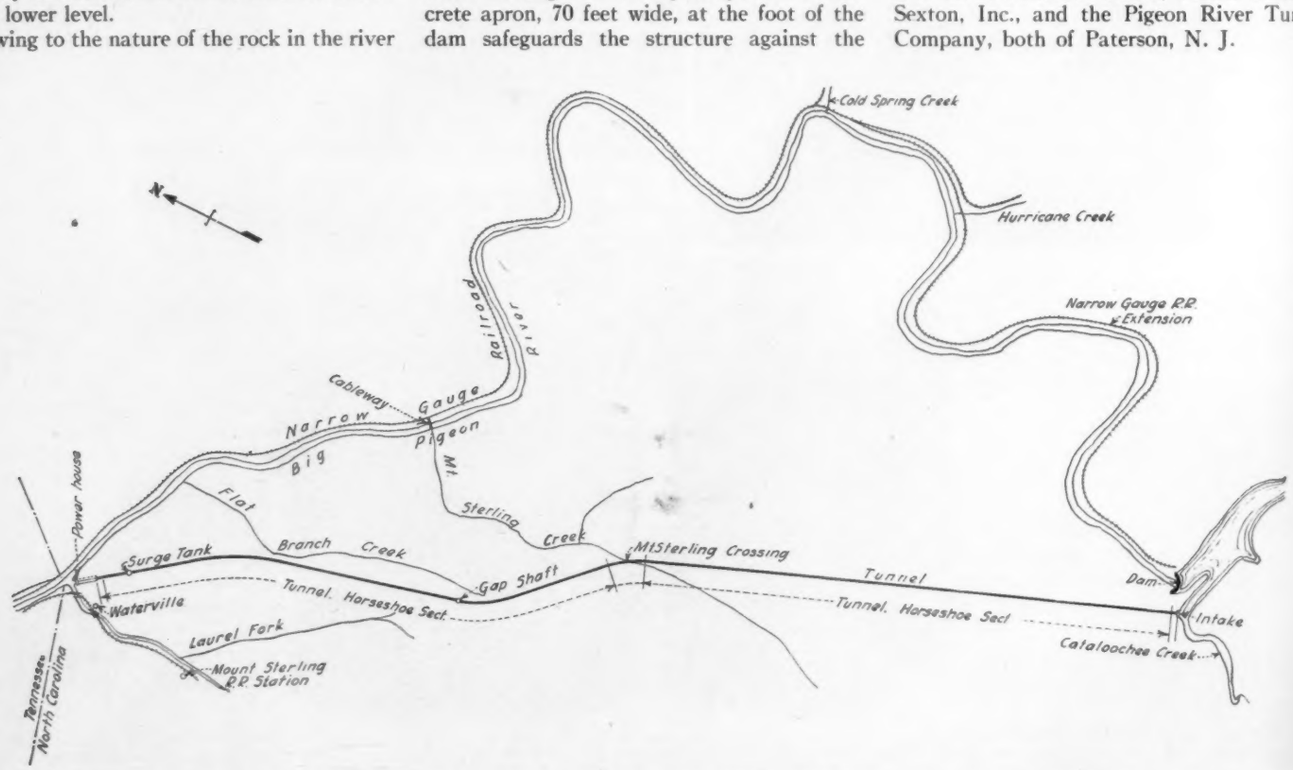
nel advance was at the rate of 18 feet per 24 hours. All told, 87,807 cubic yards of concrete were placed in the intake, the shafts, and the tunnels. A force of approximately 1,000 men was required during the driving and the lining of the tunnels.

The dam adjacent to the mouth of Cataloochee Creek is a monumental undertaking that could not be started until the extension of the logging railway reached the scene of operations. The dam called for the use of 124,184 cubic yards of concrete. The main body of the structure contains no reinforcing—the only steel employed is in the spillway piers. Two traveling full-circle cranes were used in placing all the concrete. No sand being available at the isolated site of the dam, finely crushed rock was utilized in its stead together with two coarser sizes of crushed rock. Some of this rock was mucked from the tunnel intake while the rest of it was obtained from a quarry opened on the mountainside adjacent to the railway and near the dam. A crushing plant was established conveniently on the steep slope of the valley immediately below the dam, so that the rock could be handled by gravity and fed thence to the concrete mixers on a lower level.

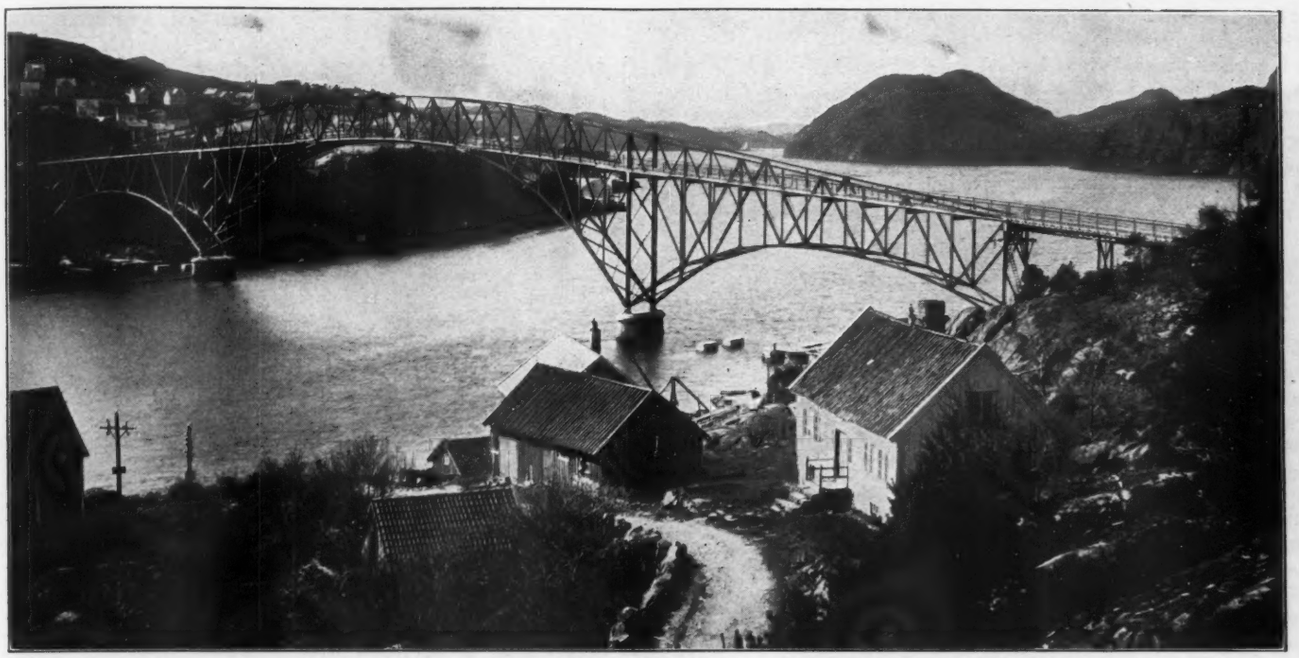
Owing to the nature of the rock in the river bed and on the steep slopes of the narrow gorge, it was necessary to excavate but approximately 35,000 cubic yards in order to insure a satisfactory bond between the rock and the concrete of the dam. During construction, the flow of the river was directed through 8 sluiceways, each 8 feet wide and 20 feet high. The rock was cleaned with air and water before pouring the concrete; and the surface of each lift was gone over with wire brushes and the freed material blown away with jets of air. Grout holes from 15 to 20 feet deep were drilled at frequent intervals in the bed rock and then charged with grout under 70 pounds pressure. It was possible, however, to force into the holes only enough grout to fill them—a sure indication of the soundness of the supporting ledge.

The dam was reared in twelve vertical sections, each about 50 feet in length; and the concrete was placed in 5-foot lifts in the heavier or lower parts of the sections and in 10-foot lifts in the thinner upper portions. This work proceeded rapidly and systematically after the connecting railway reached the site. The dam provides a drop of 180 feet to water flowing over the spillway; and a concrete apron, 70 feet wide, at the foot of the dam safeguards the structure against the scouring or erosive action of this water. Communication between the power house and the dam is maintained by a carrier-current telephone system; and the height of the water in the lake is indicated at the power house by automatic gages so that the operators there can regulate the use of water accordingly. The maximum possible seasonal drawdown is 83 feet.

As in so many other instances of work carried through unobtrusively for the common good, the general public is unaware of the existence of this great up-to-date hydro-electric plant; and in its completion we again have evidence of the enterprise of the Carolina Power & Light Company in its efforts to anticipate the steadily growing demands of its customers. The consummation of the project is cumulative proof of the continual progress industrially and economically of our wonderful Southland. While the work was in hand, the Phoenix Utility Company —the general contractor— was represented by H. F. Lincoln, general superintendent, and the late D. F. Dow, resident engineer. Robert E. Parker was general superintendent and Frank C. Sellnow chief engineer for the subcontractors, Parker-Graham-Sexton, Inc., and the Pigeon River Tunnel Company, both of Paterson, N. J.



Plan of Pigeon River and the tunnels that link the dam at Cataloochee Creek with the power house at Waterville. From end to end the connecting tunnels are more than six miles in length.



Steel highway bridge that spans the waterway between Lister and Farsund, Norway.

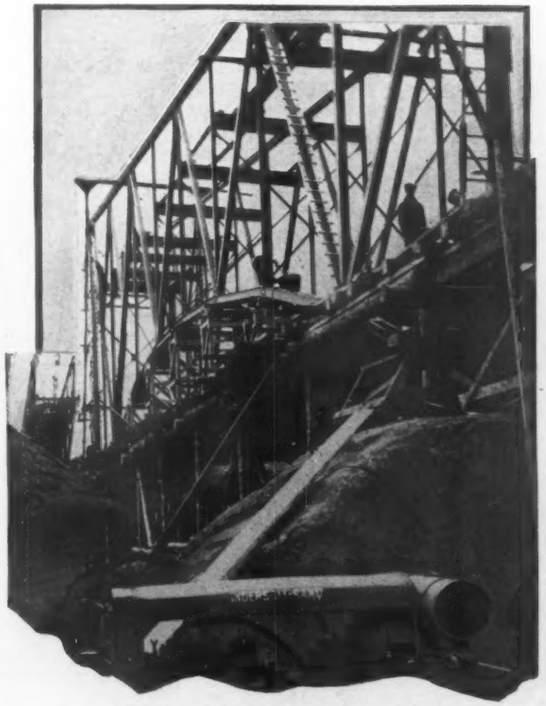
Fine Bridge Now Links Lister and Farsund

By K. LUND

NORWAY can justly lay claim to a coast combining both rugged beauty and grandeur. The country's numerous fjords that indent its seaboard bear silent testimony to the physical rigors to which the territory was subjected when the erstwhile ice cap broke up into myriads of glaciers that ground their way irresistibly toward the North Sea and the Atlantic Ocean. The ice not only carved towering headlands and far-reaching inlets, but it dug out great basins in the solid rock that now form the beds of deep fjords.

While Nature left Norway but scanty areas that would lend themselves to cultivation, still, by way of compensation, she gave the land wealth in other forms that the sturdy and industrious people of the country have learned in the course of time to turn to good economic account. The nation is shrewdly making the most of her outstanding scenic charms, and, as a consequence, draws to her annually a continually increasing number of tourists—especially in the summer months when people journey from afar to visit the Land of the Midnight Sun to see the numerous things that appeal to the eye and that are so often different from the attractions to be found elsewhere.

This annual influx has largely influenced the expansion and the betterment of Norway's highways so that modern self-propelled vehicles could make use of them. Not a few of these roads are veritable engineering triumphs that have called for the display of much skill in building and in routing them. This is especially true of some of those that skirt certain of the noted fjords. Norway's main roads had their beginnings for the most part so recently as the last half of the nineteenth century, and they were brought into being principally to facilitate transportation in regions where railroad service either did not exist or was extremely limited. Ultimately, the state as well as private enterprise started the construction of bridges to link water gaps between road ends previously served by ferries that frequently could not run because of fog or other hampering weather conditions. Bridge-building has continued to a notable extent during the last few years; and most of these structures are fine examples of that branch of the engineering art.



One of the two portable compressors that supplied air to operate riveting hammers and other pneumatic tools used in the final assembly of the steelwork.

As an evidence of this trend, we have in mind the bridge recently finished that connects Lister and Farsund, at the southwestern tip of the Scandinavian Peninsula, with the road system of the country. The strait that separates the Lister Peninsula from the Spinns Peninsula is divided into two waterways by an interposed island. Across the western strait a bridge was reared in 1895, and it is with the new structure across the eastern strait that we are dealing now. The steelwork for this bridge was fabricated at the well-known plant of Samuelsen Hölen, near Larvik. It is the biggest and the tallest bridge in that part of Norway.

The structure is made up of three spans—the middle one being almost 315 feet long and each of the two lesser spans 170.5 feet long, making a total bridged distance of 656 feet. The middle span has a clearance of a trifle more than 72 feet above the water, and the roadway has a width of 14.75 feet. The rivet-

ing of the steelwork on the site was done with air-driven hammers, and air for this purpose was furnished by two Ingersoll-Rand Type 20 portable compressors. One of these machines was the property of the contractor—the other belonging to the State Department of Highways. The latter portable is said to be the first of its kind to have been purchased in Norway.

COMPRESSED AIR ASSISTS IN TAKING SOIL SAMPLES

HANDWORK has given way to pneumatic equipment out in California in the taking of soil samples that are needed in the study of rainfall penetration. In determining the moisture of the soil for this purpose it is the practice for the investigators to take numerous samples at 1-foot intervals and down to a depth of 18 feet. As success depends largely upon the speed with which the cores are obtained, it can be appreciated that any reduction in the time between the removal of the first and the last core of a given lot is of importance. Therefore, the change in method has been a decided improvement because it has made it possible to do the work not only quickly but easily.

The equipment used consists of a truck-mounted compressor, a clay digger fitted with a soil-sampling tube, 100 feet of ½-inch air hose carried on a reel to facilitate handling, and a jack for the withdrawal of the tubes. The outfit has been in use since last October and is said to have cut down the sample-taking period by 66 per cent.

Courtesy, Public Roads

Scientists studying rainfall penetration out in California need no longer exert themselves in taking the necessary and numerous soil samples, as the pneumatic equipment shown here does it for them in far less time and, therefore, with more chance of success. For this purpose the clay digger used is equipped with a special tube.

MOTOR DRIED QUICKLY WITH AID OF HOT COMPRESSED AIR

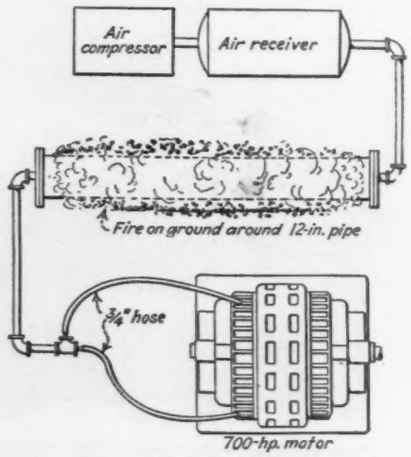
NEW ways of doing things, especially in cases of emergency, are always worth broadcasting because of their suggestive value. Therefore, the following facts concerning the drying of a flooded motor are reprinted from *Coal Age*. They tell how a motor in such a condition was restored to use without the loss of much time by the application of heat that was sufficiently high to do the work quickly and yet leave the insulation undamaged. Compressed air helped to make this possible, and just how has been described by the general master mechanic and the chief electrician of the Bessie Mine, of the Sloss-Sheffield Steel & Iron Company, Maben, Ala., where the scheme was conceived and tried out. The unit affected was the mine's 700-hp., 2,300-volt hoist motor.

Not long ago, an unusually high stage of water in the nearby river flooded the hoist house and the alternating-current substation. The water stood 4 feet deep on the engine-room floor, submerging the main hoist motor and the 14-panel switchboard with the various contactor controls. The two outdoor transformers were nearly half submerged.

The mine was not affected—that is, the water did not reach the slope portal—so the first problem was to make power available to the main ventilating fan and underground pumps. This was accomplished by running lines direct from the transformer terminals to the overhead lines, cutting out entirely the hoist-house switching apparatus. Row-boats were used by the electricians when stringing these lines; and, until the flood receded, the transformers operated by a combination air-cooling and water-cooling system.

In the meantime, plans were made for drying the electrical equipment. As soon as it was out of the water it was washed with a hose to remove the deposit of silt. The windings of the slip-ring motor showed zero insulation resistance, of course, when tested with a Megger. The first stage of drying was effected by directing blasts of hot compressed air around the windings.

For furnishing the air, a 150 cubic-foot compressor was available. As indicated by the accompanying sketch, heating was accomplished by passing the air through a 10-foot length of 12-inch pipe surrounded by an open fire. The air was directed into the windings at 20 pounds pressure by two nozzles on ¾-inch hose. By keeping the 12-inch pipe at a red heat, the air blast was maintained at about 200° F.



General arrangement of the equipment used to dry out the hoist motor.

After twenty hours, the Megger indicated a degree of insulation resistance warranting a change to drying by electric current. This was applied at 440 volts, and the rotor was alternately blocked to provide overload current for internal heating and allowed to run free for a time to induce ventilation. After ten hours of this treatment the insulation showed a resistance of 7 to 8 megohms, and the motor was ready for service.

Control magnets, overload trip coils, and other auxiliary apparatus had been removed and dried in a gas-heated bake oven. The oil switches were taken down, cleaned, and filled with dry oil.

Open wiring for power and control lines was used temporarily from motors to switchboard in place of the conduit wiring. After the old wiring had been removed, the conduits were swabbed out. The drying preparatory to installing new wiring was done by blowing heated air through the conduits. This air was supplied by the same equipment that was used in the preliminary drying of the motor.

The building of a third transandean railway has been agreed upon by the governments of Chile and Argentina, according to recent news dispatches. The route, as now surveyed, has a total length of 372 miles of which 64 are to traverse Chile and 308 Argentina; it crosses the international border at an altitude of 12,512 feet; and reaches its highest point at Chorrillos Pass lying 14,520 feet above sea level. An idea of what is ahead of the engineers in this mountainous region can be gathered from the fact that in one instance it will be necessary to construct eight miles of line in order to advance a mile. The new road will shorten the present rail run between Antofagasta, and Salta by 68 miles.

Stoneyhurst Quarries Produce Beautiful Building Material

The Story of These Quarries is the Record of a Woman's Mastery of a Difficult Economic Situation

By J. S. MEEHAN

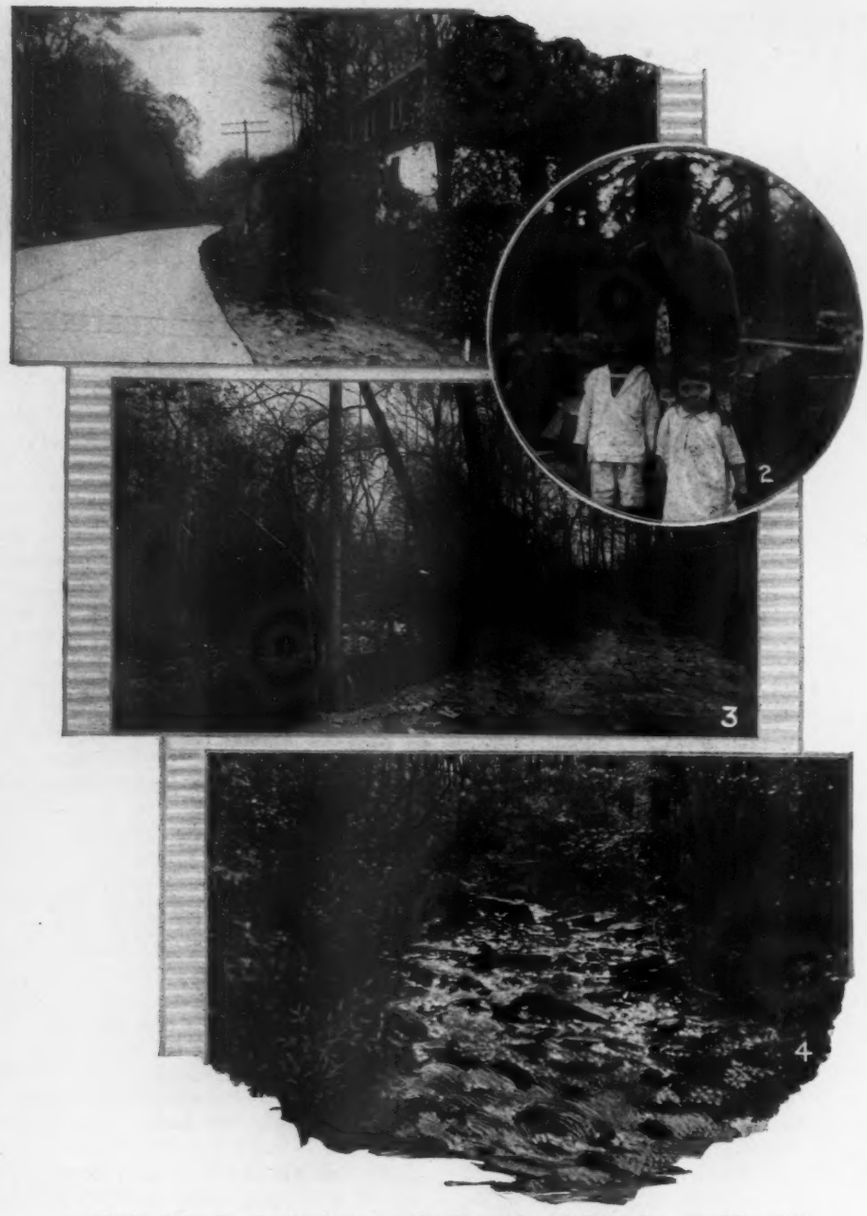
COLORFULNESS is the order of the day: it confronts us at every turn. And colorfulness in stone is adding much to the architectural charms of structures in certain sections of the District of Columbia and its environs. This agreeable state is due in no small part to the output of the Stoneyhurst Quarries, situated near Bethesda, Md., and two or three miles to the north and west of the District line.

Stoneyhurst Quarries—there are three openings—unquestionably owe their present prominence to the courage and to the enterprise of their resourceful owner, Mrs. Lily C. Stone. Mrs. Stone turned to and made outcropping ledges profitable when the broad expanse of her inherited acres proved incapable otherwise of yielding her a comfortable livelihood.

While Mrs. Stone has set her sex a fine example in meeting a difficult situation undismayed, still she thus classified herself recently: "I may not be brilliant, but I believe I have good common sense." We are inclined to doubt the conclusiveness of her modest self-estimate. Brilliancy, when all is said and done, is but another term for achievement; and this becomes especially true when success is won despite heavy handicaps. No one can deny that the odds were against this Maryland woman when she started to operate the quarries that have since made her widely known.

Mrs. Stone's grandfathers, on each side of the family, fought in the Colonial forces during the War of Independence, and it was from one of those sturdy-spirited forebears that her present lands descended. The property has been in the family for more than 160 years, and has an expanse of 500 acres made up of wide-open spaces and wooded hills.

Left—This gives a good idea of the shallowness of the overburden covering the rock on the property. Right—Circumstances and modern equipment make it possible to get out the rock with relative ease.



1—Cabin John Road which passes the Stoneyhurst Quarries. 2—Mrs. Lily C. Stone and her grandchildren. 3—Cabin John Creek and the old road over which stone was hauled to the Chesapeake & Ohio Canal. 4—One of the several picturesque brooks on the Stone estate.

While the soil, where cultivated, is measurably fertile, still, for the most part, it is scarcely more than a thin overburden covering rocky strata that come close to the surface.

In the springtime, the ground is moist from melted snows and seasonal rains, and then everything is fresh and green; but later on the hot sun of summer well-nigh invariably extracts the last of the residual moisture and the grass and the garden crops wither wherever it is impossible to irrigate them. In short, the property is unsuited to general farming even though it may appear so to the casual eye. Such being the condition, for years before the crisis came, Mrs. Stone and her invalid husband utilized the land for the raising of livestock and for the boarding of other peoples' horses that were turned loose to graze in the open fields and pastures as long as there was subsistence there for them. But the coming of the motor truck and other self-propelled vehicles sounded the doom of the horse; and Mrs. Stone, bereft of her husband in the meanwhile, was forced to cast about her for another source of revenue.

It was while she pondered what next to do that she recalled a remark made by her father shortly before his death, as if anticipating just what had come to pass. He said to her: "If you are ever hard put to it and need money, be sure to work the quarries." Good as that advice has since proved itself to be, nevertheless the doing of work of that sort was wholly unfamiliar to Mrs. Stone. Unknown to her, however, she may have inherited capabilities that fitted her to operate quarries. One of the openings on her property had been worked by one of her grandfathers who had been engaged in the construction of the old Potomac Canal that later became an integral part of the Chesapeake & Ohio Canal. Mrs. Stone's grandfather got out rock from that quarry and used it to build retaining walls, culverts, etc., along that historic waterway. The stone was drawn by mules over a narrow-gage railway that ran from the quarry to the canal about two miles away.

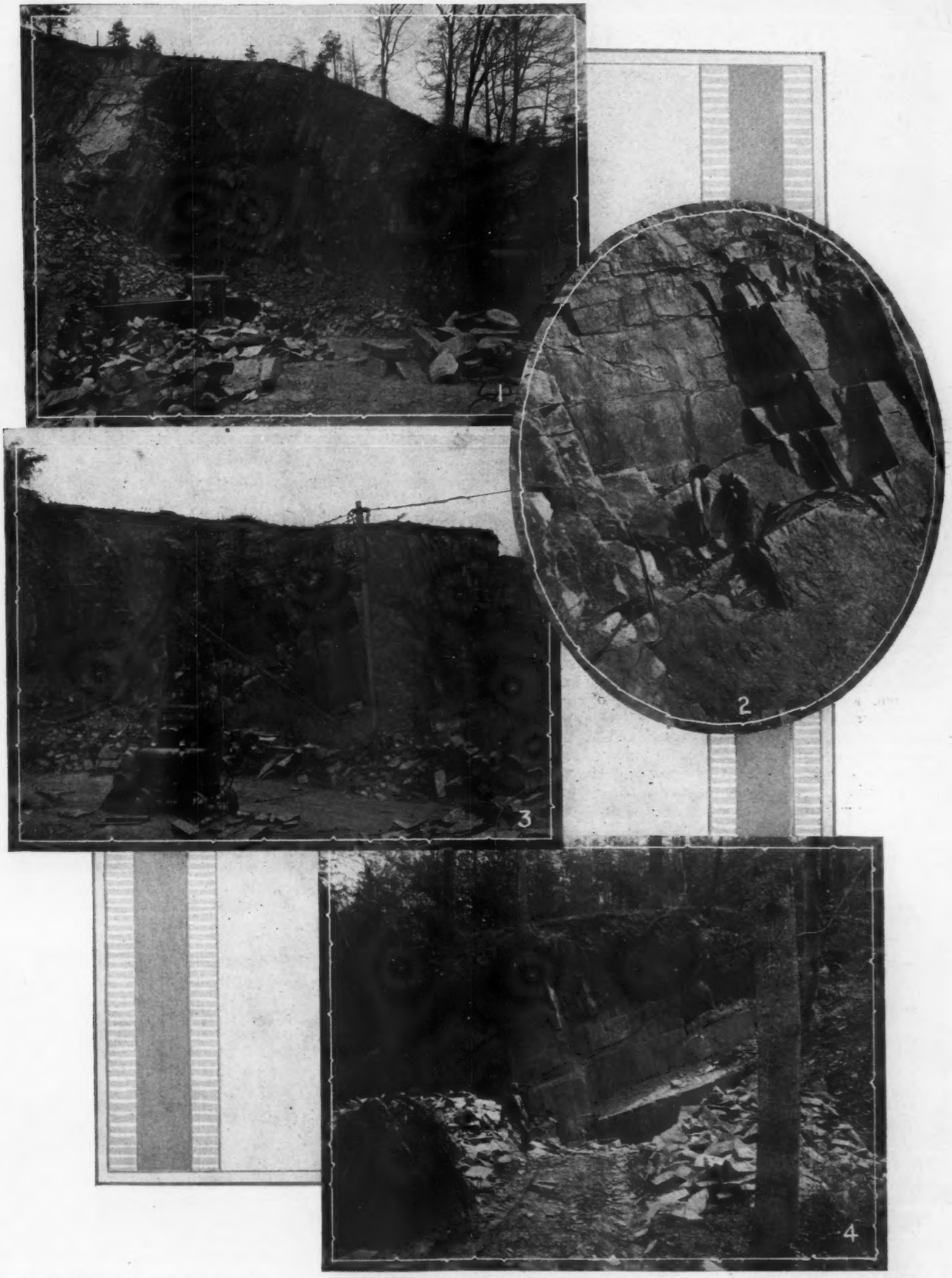
The old Potomac Canal was the direct outcome of the leadership of George Washington, who counted upon the canal to aid in linking the potentially great commercial empire of the trans-Alleghany region with the seaboard via the Valley of the Potomac. Work on that water route reached its climax shortly before Washington was elected to the presidency. From the old quarry operated by Mrs. Stone's grandfather, Mr. Moore, there still are taken large slabs of a hard-grained mica schist that lend themselves admirably to certain special uses. Thus, Mrs. Stone has an industrial background that may have equipped her for her present activity.

Quarry No. 1 was bought at the instance of Mrs. Stone's father; and it is from Quarry No. 1 rather than from the two inherited quarries that she gets most of her rock for building purposes. Before she began to open up Quarry No. 1, the only surface indication of the ledge was where a seasonal rivulet had, in the course of time, washed away the overburden of earth and had left a small area of mica schist exposed. Four years ago she started operations there as a gamble, and by way of economy she bought a secondhand truck to haul the stone to customers. But before she purchased that truck she took samples of the rock to the United States Bureau of Standards for examination. As a result of a series of tests, the physical characteristics of the brown- and the gray-mica schists were established, as shown in an accompanying table.

We are informed that an official of the Bureau expressed the opinion that the stone would create a new era in architecture. The brown rock ranges in color from a soft buff down to a deep rusty hue often shot with streaks of purple, while the gray stone is far more restricted in its chromatic scope. Properly distributed throughout any broad surface, the gray and the brown varieties produce an extremely mellow and pleasing effect. Mrs. Stone's present home was built in 1767—thus affording convincing evidence of the durability and the weathering quality of the rock from the quarries on her estate.

	Compressive Strength Lbs. per sq. in.	Absorption	Specific Gravity	Weight, Dry Lbs. per cu. ft.
Brown	19,985	0.632	2.74	171
Gray	21,840	0.208	2.80	175

The Stoneyhurst Quarries have furnished stone for various purposes within the Close of the Washington Cathedral. It has been used to floor the Chapel of Joseph of Arimathea and to build the Canon's House, the Shadow House, the Parish House, and Preach-



1—Stratified ledge, at Quarry No. 1, which makes it easy to get out flat-sided slabs for architectural purposes. 2—Close-up of a "Jackhamer" drilling holes for bringing down rock in one of the Stoneyhurst Quarries. 3—Portable compressor that supplies operating air at the Stoneyhurst Quarries. 4—Oldest quarry on the Stone estate which first furnished material used on the historic Chesapeake & Ohio Canal.

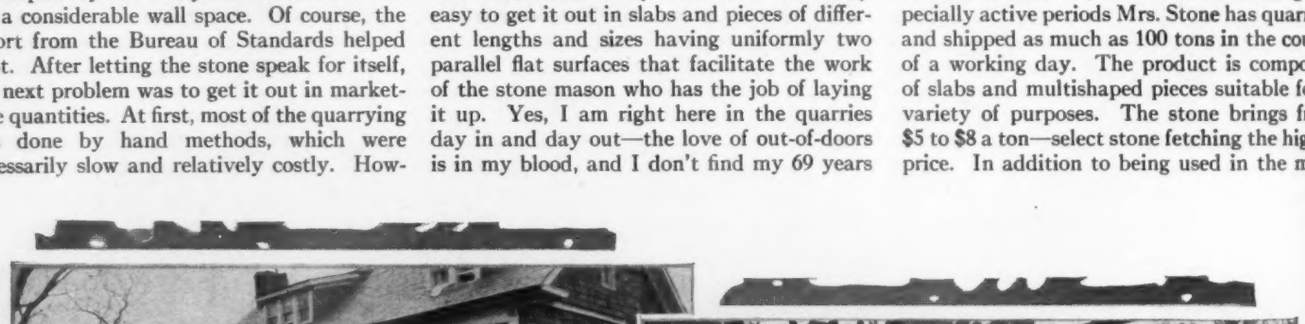
Two excellent examples of the way material from the Stoneyhurst Quarries lends itself to the purposes of the architect.

ers College. It is also being utilized in a large dormitory under construction on the property of the American University, in the District of Columbia; and it has been and is being widely employed in homes that add much to the architectural beauty of Washington and its suburbs.

Knowing how keen is the competition in structural materials, one reasonably wonders what Mrs. Stone did at the very start to obtain recognition after she had had her mica schists tested by the Government experts. She explains her success in this way: "I took a number of samples showing all the coloring to the architects in Washington, and some of them were impressed immediately while others came to admire the stone later on—especially when they saw it laid and covering a considerable wall space. Of course, the report from the Bureau of Standards helped a lot. After letting the stone speak for itself, my next problem was to get it out in marketable quantities. At first, most of the quarrying was done by hand methods, which were necessarily slow and relatively costly. However, before the end of my first year of venturing in an unfamiliar business I managed to make enough to supplement my original secondhand truck with a larger and better one built to order. That year also taught me the need of doing my drilling mechanically. On the advice of a brother-in-law, who had done much mining in the Southwest, I bought a portable air compressor and an air-driven 'Jackhamer'. These 'pneumatics', as I call them, have performed splendidly and have saved me much time and money since I bought them. I also purchased a rotary air hoist, and this is used to pull loaded cars up a 60-foot grade from the floor of the pit to the top of the quarry.

"As you can see, the stone is so stratified and seamed naturally that it is relatively easy to get it out in slabs and pieces of different lengths and sizes having uniformly two parallel flat surfaces that facilitate the work of the stone mason who has the job of laying it up. Yes, I am right here in the quarries day in and day out—the love of out-of-doors is in my blood, and I don't find my 69 years any handicap to my getting around. You might think that my interest in the stone ceases with quarrying and shipping it, but such is not the case. I find I can often help the masons by suggesting how the different colored stones should be distributed so as to avoid patchiness and to insure a uniformly pleasing general effect. A visit to a building site guides me in dispatching subsequent loads of stone to make certain that the masons will have a suitable variety to choose from."

Although mica schists from Mrs. Stone's property were tested by the Bureau of Standards in 1924, it was not until two years later that she began the work in which she has succeeded so well. Each twelvemonth since has shown increased recognition. The output in 1929 totaled 10,785 tons; and during especially active periods Mrs. Stone has quarried and shipped as much as 100 tons in the course of a working day. The product is composed of slabs and multishaped pieces suitable for a variety of purposes. The stone brings from $5 to $8 a ton—select stone fetching the higher price. In addition to being used in the main



Left—The Stone homestead built in 1767 with rock quarried on the estate. Right—Preachers College, at Mount Saint Alban, built of stone from the Stoneyhurst Quarries.

walls of structures, it is worked into retaining walls and employed for window sills, steps, flagging, etc. Mrs. Stone's transport equipment is made up of six motor trucks—a marked increase over the single secondhand unit with which she began business.

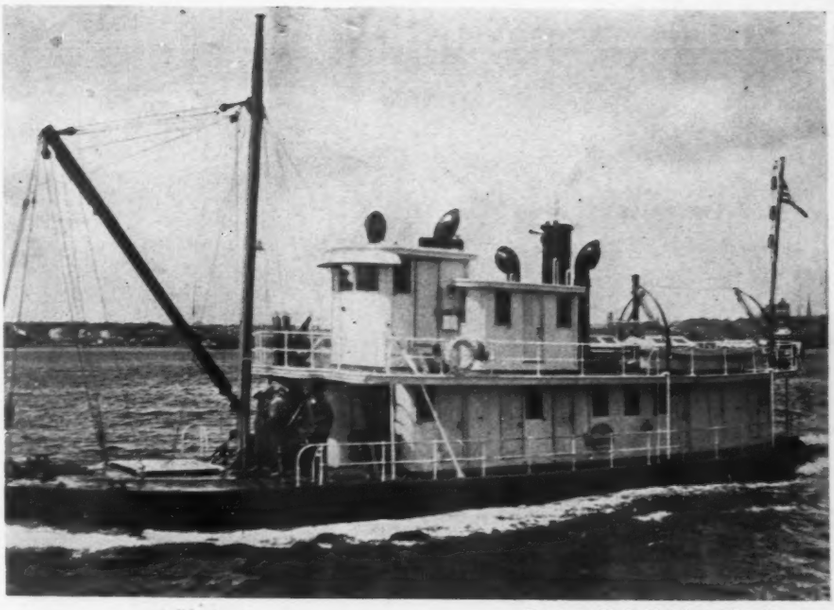
Apart from her display of managerial capacity—she has a working force of 30 men, Mrs. Stone has manifested a great deal of business shrewdness. Time and again she could have obtained sizable contracts at a low figure that left but a small margin of profit. She has invariably declined such ventures. As she expresses it: "I have always sought a price that would insure a safe profit; and low-priced contracts involve too much risk of a loss. I don't believe in business just for the sake of business."

Notwithstanding the insistent demands made upon Mrs. Stone in negotiating sales and in generally supervising operations at her quarries, she finds plenty of time to give to her home and to her grandchildren as well as leisure—if you can call it such—that she devotes to church work and to the activities of the patriotic society with which she is identified. What she has done on her own responsibility and what she is doing in carrying on her constructive work are heartening and inspiring evidences of how capacities seemingly in reserve can be mustered effectively when an emergency arises in one's life. Mrs. Stone's success offers encouragement to either man or woman similarly situated.

UNDERGROUND SHOVEL FEATURES SMALL DIPPER

IN compliance with service requirements, the Nordberg Manufacturing Company is now in a position to provide either a 5- or a 7-cubic-foot-capacity dipper with its air-operated, full-revolving underground shovel. Until recently a 7-cubic-foot dipper was used exclusively, but this was found to be too large to handle with ease heavy concentrates at smelters or to dig clay or kindred materials directly from the bank without blasting. To overcome these difficulties the smaller dipper was designed; and it is said to offer considerably less resistance than the 7-cubic-foot dipper when working in sticky ground. It is also possible for a shovel so equipped to operate in drifts a little more than 5 feet wide—in fact, the new dipper has cut down the swinging room heretofore necessary by 4 inches.

The United States Tree Commissioner stationed at Oslo has recently announced the fact that a Norwegian engineer has to his credit the discovery of a solution that robs flames of their destructive power over wood as well as paper. This, he writes, was demonstrated when repeated attempts to burn down a frame structure, treated with the solution, failed. The preparation, the name of which has not been divulged, is soon to be produced on a commercial scale. Chemicals to make wood fireproof have been produced before this, but none, so far as we know, has been put to extensive use.



Courtesy, U. S. Lighthouse Service

New United States Lighthouse Tender "Althea" serving the Intracoastal waters of South Carolina, Georgia, and Florida. All water used aboard this vessel is distributed by compressed air.

CHROMIUM PLATING GIVES METAL LONGER SERVICE LIFE

IMPORTANT savings in time and production costs have been reported by the Ford Motor Company as the result of the application to gages, tools, and certain machine parts of a hard chrome plating. It has long been known that such a protective coating would increase their service life; but the problem has been just how to do the plating so that the chrome would not peel or chip off. This has now been solved; and gages that formerly stood up under specific grinding operations for but four hours are now capable of doing 218 hours of effective work. Aside from the large reduction in cost thus effected, the amount of scrap—that is, the number of parts rejected in course of manufacture—is less because the gages retain their close limits longer.

Standard Nordberg-Butler underground shovel equipped with the new 5-cubic-foot dipper designed for special uses.

COMPRESSED AIR DISTRIBUTES WATER ON SHIPBOARD

AFTER successfully passing her trial trips off Groton, Conn., the new lighthouse tender *Althea* has taken up her duties of erecting and maintaining aids to navigation in the inland waters between the Cape Fear River, N. C., and Miami, Fla. This stretch of the inland route, extending along the Atlantic seaboard all the way from New York to Florida, is much used by small pleasure craft; and it was for service in these waters, that are now being deepened to 6 feet by the United States Army Engineers, that the *Althea* was especially designed.

The *Althea* is a thoroughly up-to-date craft, and embodies some unusual features. Her propulsive power is furnished by two Diesel engines driving twin screws; and she has two rudders that facilitate steering her in narrow channels. Conspicuous among the deck machinery is a big derrick for the handling of piles, buoys, and other heavy supplies that her duties as a lighthouse tender compel her to carry. In fact, she is self-contained in every respect, even to a pile driver—her shallow draft of 3½ feet enabling her to get close to the shore to plant piles in the erection of guiding lights. One feature in which the *Althea* differs from most craft is in the matter of handling water. There are no water or sanitary pumps aboard of her; she depends entirely upon compressed air—that is, air pressure, to force the water from the respective tanks to any point desired.

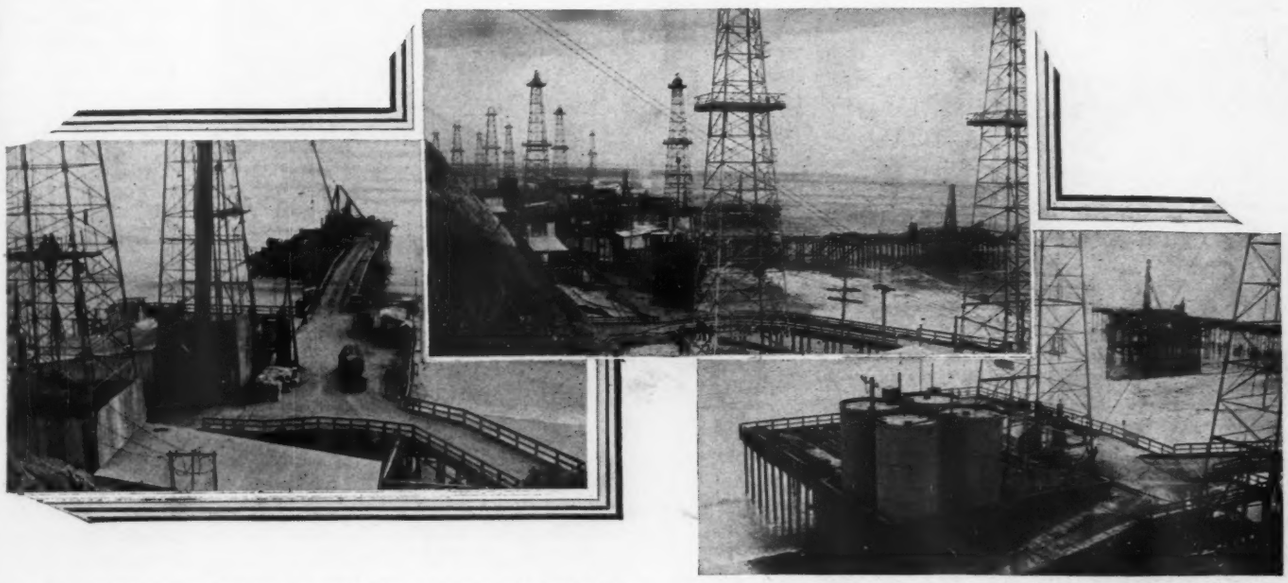
Standardization has struck the doughnut industry—a machine for their baking having been invented that makes use of a pneumatic cutter to turn out a uniform product.

Ewing Galloway, New York

Campanile and some of the associate buildings of the civic center of Springfield, Mass. That city may well be proud of this well-balanced and fine architectural effort.

Conserving Gas in the Production of Oil In Southern California Fields

By R. H. PENCE*



Left—A land well offsetting a well drilled below high-tide level. Another well is located at end of pier. Center—Producing wells on tide land. Right—A complete producing unit set below high-tide level. Pictures taken in Elwood Field, Calif.

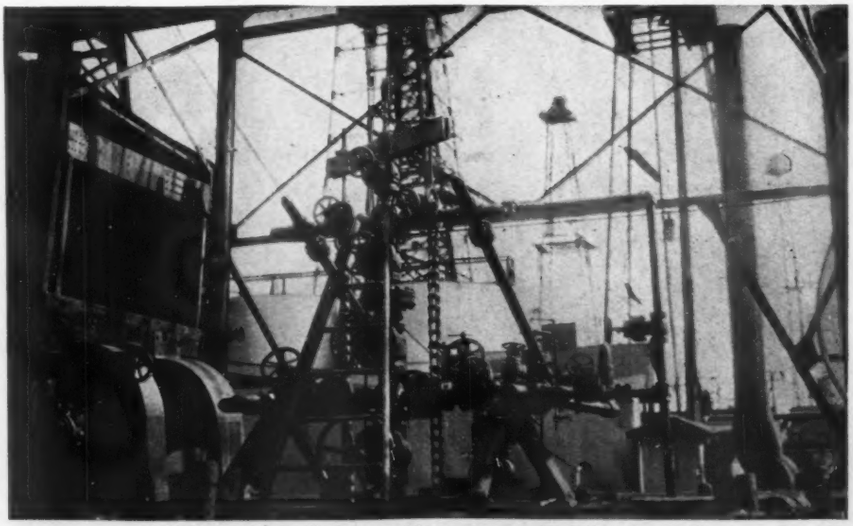
NATURAL gas in the oil fields is no longer generally considered merely an incidental part of the recovery of petroleum—something to be wasted or conserved as circumstances dictate. Petroleum engineers are alive to the fact that the gas is the primary agent that moves the oil through the sand and toward a well—aiding by just so much in the ultimate recovery of oil and in the economies of that operation. Furthermore, the value of the gas extends beyond that service, inasmuch as the gas, *per se*, is marketable and usable for a variety of purposes.

Conditions being such as we have outlined in the foregoing paragraph, the wisdom of the California Gas Conservation Law becomes apparent; and the effectiveness of that legislation has already been manifested in that high-pressure gas area known as the Santa Fe Springs Field. The passing of that conservation law aroused a good deal of consternation among a considerable number of operators, and most of these were outspokenly against the law, armed as it is with effective teeth. Notwithstanding widespread antagonism, still many of the operators in the Santa Fe Springs Field have taken steps to cut gas production, and they have generally succeeded in reducing it to a point in agreement with the order of the court.

Fortunately, the court order, instead of fixing a gas-oil ratio of production, allowed each operator to produce a given volume of gas. Basing the order upon the actual consumption of gas in and from the field, as well as upon the probable further oil production of the field, a satisfactory ratio was arrived at. The ratio came to 1,200 cubic feet of gas per barrel of oil. Thus an operator's oil potential when multiplied by 1,200 gave him the volume of gas that he was allowed to produce regardless of the amount of oil that could be lifted with that volume.

In an earnest endeavor to comply with the court's order, the operators have tried various methods of controlling gas production. Oil production must be sufficient to meet the payroll; and it is the oil that determines whether a gas-control method is a success or a failure. In short, if the oil production were greatly reduced by bringing down the gas production to that permissible, the method would, of course, not be acceptable to the operator. The oil is his first consideration. The willingness of the operator to obey the court's order therefore depends entirely on oil production.

The first step taken to regulate the flow of gas consisted of beaning a well, causing the well-head pressure to rise. But this procedure not infrequently also decreased the oil production so much that it was not looked upon with favor. Another experiment in this direction was to lower and to adjust the size of the tubing already in the well. Where this was tried a great improvement was noted. In a well that was producing through



"Christmas tree" after tubing was run in a flowing well.

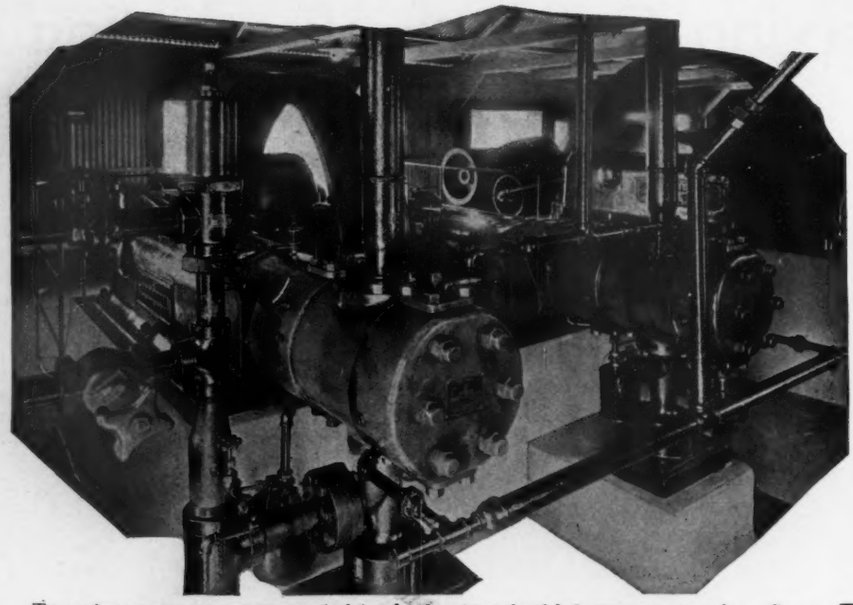
*Signal Engineering Company.

the oil string and without tubing it was found that the injection of tubing through a special head, and while the well was still flowing, was entirely satisfactory. This procedure, which has been practiced for years in the Gulf Coast District, is now used for the first time and with success in California. The running of tubing in many of the flowing wells in that State has not been attended by a single accident nor by any great difficulty.

A new use has been discovered for the gas lift in this attempt to conserve gas. In many instances the injection of gas under high pressure into the casing of a tubed well has reduced the expenditure of formational gas to a great extent even while maintaining a fair production of oil. The theory is that the injected gas relieves the formational gas of much of the work of lifting the oil to the surface and necessitates the use of only enough formational gas to move the oil from the sand to the well. This adaptation of the gas lift functions effectually when the tubing is set deep in the well. Back pressure must, of course, be applied by beaning so as to control the influx of both oil and gas.

High-pressure equipment is essential to this method, thus widening the field of usefulness of high-pressure oil and gas separators. Instead of compressing the gas that needs to be injected into the well by means of an ordinary 2-stage compressor, high-pressure oil and gas separators are installed, allowing gas at 200 pounds or more to pass from the separator into the high-pressure compressor cylinder. By substituting a high-pressure cylinder for the usual low-pressure cylinder on a 2-stage compressor, the machine can be made to handle a greatly increased volume of gas with little if any additional power. There have been cases where from 2,000,000 to 4,000,000 cubic feet of gas, at pressures ranging from 500 to 700 pounds, have been injected into well casings. This adaptation of the high-pressure separator and the modifying of old compressors have combined to decrease to a considerable extent the unit cost of compressor equipment.

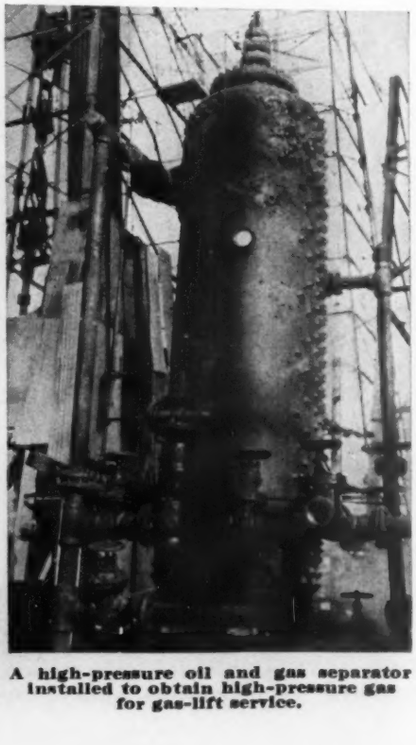
Another method of control has been developed by the writer that has proved to be effective on high-pressure gassy wells. It consists of circulating oil in wells that are tubed deeply. Offhand, this sounds absurd, but the method has merit. It has been demonstrated that oil injected into the casing increases the weight of the column of gas and oil flowing out of the well, thus, in effect, serving the purpose of a bottom bean. The added oil also takes up space in the tubing ordinarily occupied by high-pressure gas, in that way making sure of the required velocity of outflow. The ratio of the circulated oil to the oil coming from the formation varies between 40 and 80 per cent. However, the figures must be determined by experimental means. The choice of a pump for this service is a big factor. The use of the large "mud hog", running at slow speed, has proved to be anything but satisfactory because the oil is not injected in a steady stream, and therefore causes the well to head. A smaller pump, operating at fairly high speed, is much more suitable. This procedure cannot be counted upon to cure all ills, and has been found to work successfully only in the case of wells with a big kick and a lot of gas.



Two-stage compressor converted to single-stage for high-pressure service. Compressor uses gas from high-pressure separators for control of formational gas from flush wells.

There are now available some excellent bottom beans that can be adjusted from the surface and that would undoubtedly fill the bill in every way. Under circumstances the use of small tubing at the bottom of the tubing string has served admirably. The small tubing, by restricting the area, tends to maintain the pressure at the lower end of the tubing and permits only just enough gas to flow from the well to lift the influx oil that comes from the formation. But little pressure is required at the surface. As a matter of fact, when bottom beans or small bottom-end tubing are utilized, the lower the pressure the better—so far as gas-oil ratios are concerned.

Gas conservation is practicable: the Santa Fe Spring's operators have proved it conclusively. They have shown that with proper facilities it is entirely feasible to bring wells in without wasting great quantities of gas. Since the California Gas Conservation Law became effective, curves plotted of the field and of individual wells indicate that the decline in the gas has been arrested to a marked extent. These curves are graphic evidence that oil can be recovered at a considerably lower expenditure of gas than was previously deemed essential to oil production; and this, in the last analysis, means that much larger quantities of oil will ultimately be recoverable.



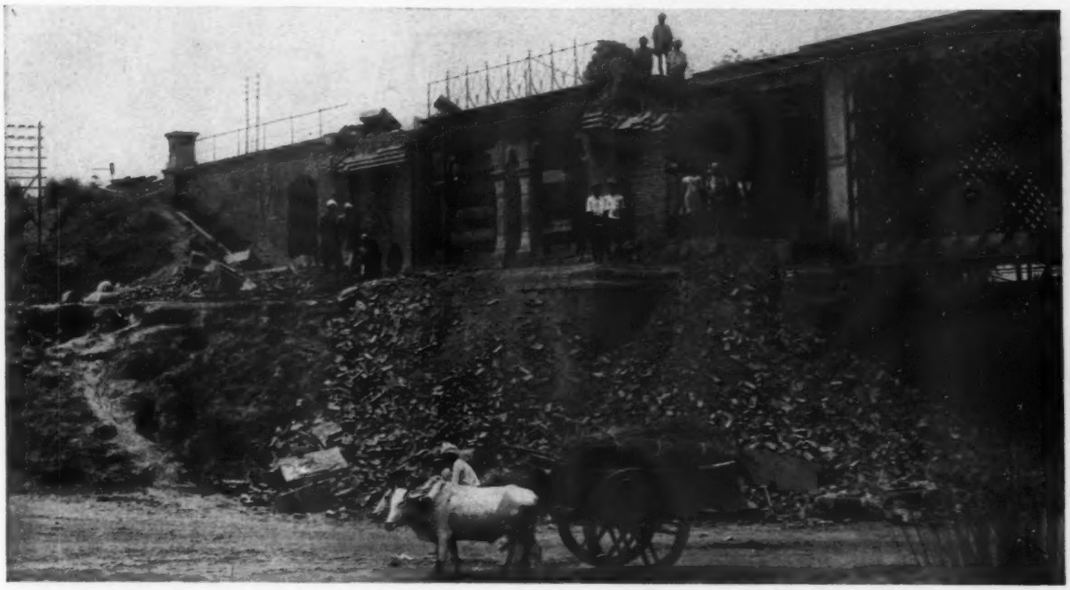
A high-pressure oil and gas separator installed to obtain high-pressure gas for gas-lift service.

FILM TELLS STORY OF SULPHUR MINING IN TEXAS

THE United States Bureau of Mines has announced the release of its newest motion picture entitled, *Sulphur*. This mineral is mined in a most ingenious fashion by the aid of hot-water and compressed-air pipes that are carried down to the sulphur-bearing domes—the hot water serving to melt the mineral underground and the compressed air to bring the fluid sulphur to the surface. All these things are illustrated, as well as the distribution and the utilization of the product. It might be of interest to add here that the United States produced about 2,000,000 tons of sulphur in 1929 or more than 80 per cent of the world's total—the Gulf States of Louisiana and Texas supplying most of this material.

Copies of the film may be obtained by educational institutions, business and civic organizations, and the like upon application to the Pittsburgh Experiment Station, United States Bureau of Mines, Pittsburgh, Pa. No charge is made for the use of the film other than the cost of transportation.

Old Bridge in India Strengthened for Present-Day Heavier Traffic



Paving breakers speedily broke up the massive brick abutments of the Lower Sone Bridge.

By C. H. VIVIAN

COMPARED to the United States, India is a country of few railroads. Its 40,000 miles of lines serve an area of 1,803,000 square miles and a population of 320,000,000. This figures out, roughly, one mile of railroad to every 47 square miles of territory and to every 8,420 persons. In the United States there is one mile of line to every 11 square miles and to every 420 persons.

The government owns some 70 per cent of India's railroads and operates 20 per cent of the lines. One of the principal roads under government control is the East Indian Railway. It has 6,000 miles of track and serves the lower Ganges Valley, the most densely populated section in the country. Near Patna, in the geographical subdivision of Bihar, the line crosses the Sone River near its confluence with the Ganges. Since another branch of that road crosses the Sone at a point farther upstream, the bridge close to Patna is known as the Lower Sone Bridge. This bridge is of the girder type on masonry abutments, and was originally built during the period from 1854 to 1867. After continual use in carrying main-line traffic, the superstructure reached such a condition by 1914 that it was incapable of bearing unrestricted traffic. Regirdering was decided upon, but was delayed until 1925 when the girders carrying one of the two tracks were replaced. Regirdering for the second track, known as the "down track", was done during 1929.

Since the new girders are considerably larger than the old ones, the work was conducted so that the existing steel could be used as falsework in the erection of the new structure, thereby facilitating operations. Following the placing of the new girders, the old framework was cut apart and removed, piece by piece. Several preliminary operations, however, were necessary before the actual construction of the new girders could be begun. First, the pierheads had to be rebuilt, to provide masonry seatings for the new girders. Next, since the center line of the new girders was 61½ inches from the center line of the old girders, the latter had to be moved sideways that distance to put them in position to serve as falsework. Incidentally, to accomplish these two things, the old girders—each of which weighed 120 tons—had to be underpinned, raised, and then lowered.

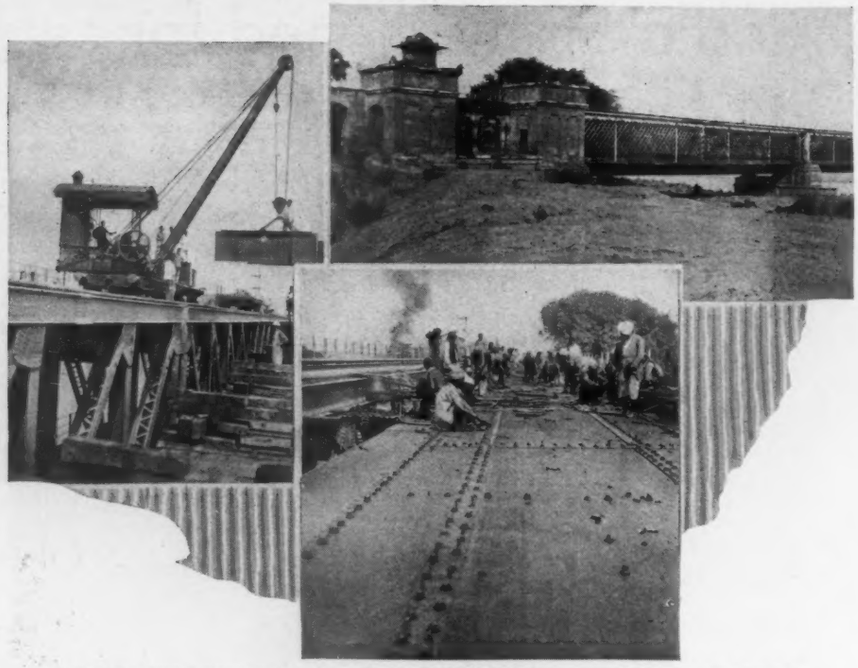
Reconstruction was done almost entirely with native labor; and all the steel used was made in India. The steel parts were fabricated with such precision that similar members were interchangeable; and the quality of the material was found to compare very favorably with that of European manufacture.

The work was completed in October, ten months after it was started. A total of 3,500 tons of old girders was dismantled and replaced by 6,085 tons of new steel. The erection of the new girders called for the driving of 485,000 rivets after the material was delivered on the job. In addition, considerable riveting was done in the yards adjacent to the site. The cost of the reconstruction was approximately $900,000. The engineer in charge of the work was Henry S. Kerr, district engineer of the East Indian Railway.

Compressed air was used throughout for the operating of tools. A power house, located on the west bank of the river, contained five compressors—two steam-driven and two oil-engine-driven stationary machines, and one portable gasoline-driven unit. These compressors had a total piston displacement of 1,120 cubic feet per minute. An air line, consisting of 1,500 feet of 6-inch pipe and 3,000 feet of 4-inch pipe, was laid from the power house across the bridge and provided with take-offs every 40 feet. At these take-offs, manifolds with 4-point connections were fitted as required. A second air line, of 4-inch diameter, extended 500 feet to the yard to supply tools working on riveting at that point. Numerous Ingersoll-Rand No. 8A riveting hammers and holders-on were used on the bridge, itself, while Size BB drills and No. 8 close-quarter drills did all the drilling and reaming. Yard riveting was done with yoke-type riveters. Other air-operated equipment—such as rivet cutters, paint sprays, sand blasts, and CA-35 paving breakers, were also utilized.

The first step was to demolish the brickwork on the outside sections of the piers and to lay new outer bearings for the new girders. The new bearings were of masonry, and consisted of three courses of Mirzapore and Chunar stone built up in pyramidal form by progressively decreasing the area of the cross section of each course. The stone for the outer bearings was handled by a railroad crane mounted on the old track. This part of the work was done before the existing girders were disturbed.

After the outer bearings had set, a steel trestle was erected upon them. Then a jacking beam was supported at one end by this trestle and at the other end by a bracket bolted to the end post of the adjacent up-track girder. Cleats resting upon this beam were next bolted to the end of the old girder. By placing one of these beams at each end of the girder, it was possible to jack up the



Left—Lowering structural steel into position by means of a crane on the adjacent track. Right—One of the original abutments which served as fortifications during the Indian Mutiny in 1857. Bottom—Riveting the new steel deck plates.

span and to underpin it. The old girder bearings were then removed from the pierheads by a crane on the "up track"; the existing brickwork was cut out; and the new masonry bearings laid in place.

The bearings were given four days to set before the old girder was moved into correct position to serve as falsework for the new girder construction. The shifting was accomplished by placing two 50-ton jacks at each end of the girder; pushing against the end posts of the adjacent up-track girder; and sliding the old girder along the jacking beam. A trestle was then erected on the inner masonry bearings, and braced together with the trestle on the outer bearings to form a tower. That done, the end of the jacking beam resting on the bracket bolted to the up-track-girder end post was jacked up and the weight transferred to the inner trestle.

The old girder was lowered 61 inches on to timber sills laid on the new masonry bearings. This was done in 6-inch steps by means of four 50-ton hydraulic jacks placed one under each corner of the span at the trestles. Each pair of jacks at opposite ends of the girder was connected to a common pump, thus automatically equalizing the load and keeping the girder level across the ends while it was being lowered. By means of tackle, moored to the adjacent up-track-girder end posts, it was possible to maneuver the girder into the exact position desired.

The complete operation of underpinning, laying inner bearings, moving the girder over, and lowering it averaged four days for each span largely because of the time taken by the mortar of the inner masonry bearings to set. Towards the end of the work quick-setting cement was used and spans were lowered every two days. After a span was lowered, holding-down bolts were put in place in the bed stones of the masonry bearings.

In order that the erection cranes might work at rail level at all times, the deck for the new girders was constructed first. The deck for each span was assembled in eight sections in a yard adjacent to one end of the bridge. These sections were transported to the site and swung by the crane working on the up track into position on timber cribs built up to the proper height. Rough track was run on this new deck to accommodate a crane used in laying erection support beams. These consisted of double 12x5-inch wooden joists and were slung in stirrups bolted to the bottom member of the old girder at the panel points of the new girder.

Demolishing one of the old abutments with CA-35 paving breakers.

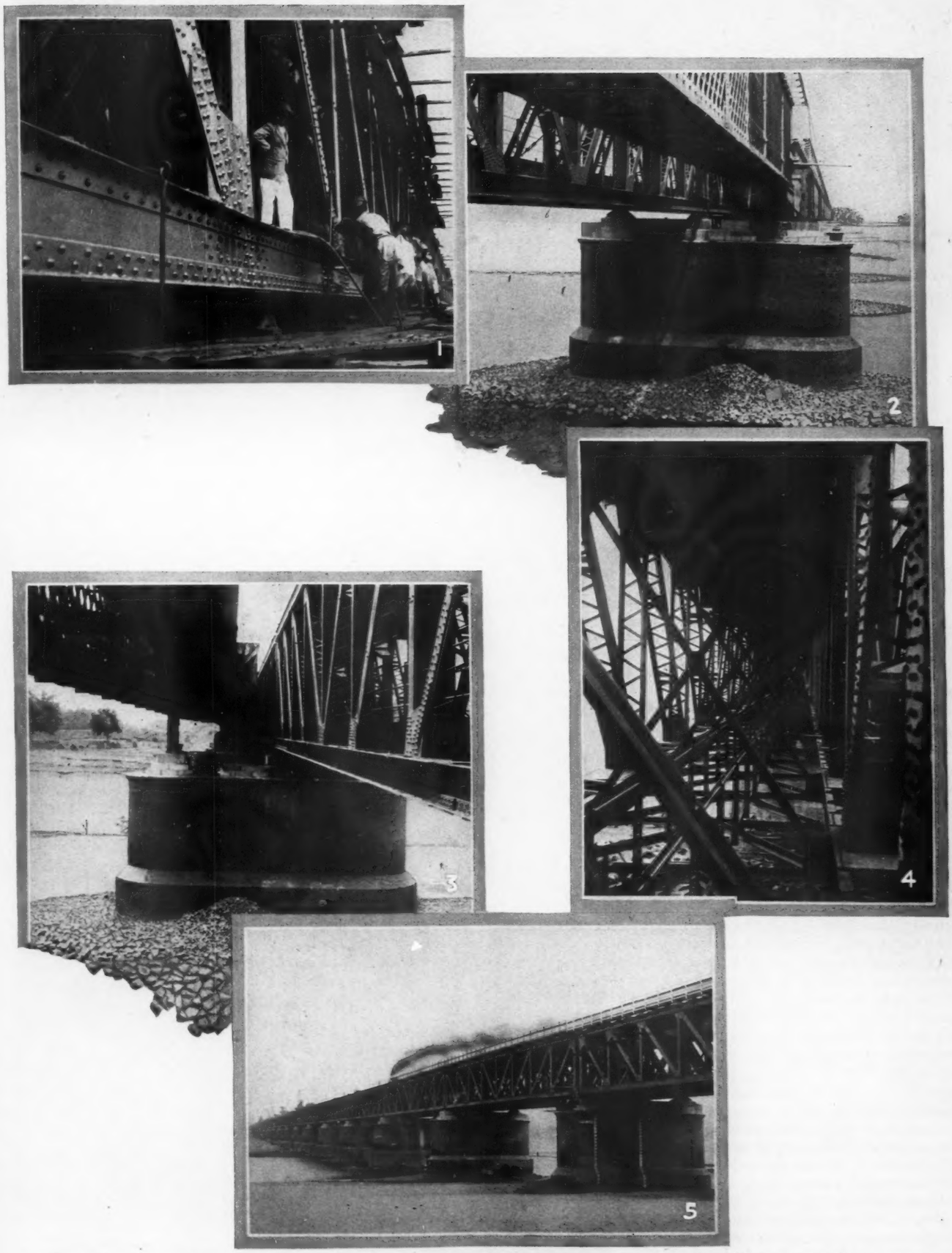
Jacks were set on the support beams to give the span the correct camber—the steel being such as to provide for a span 1¼ inches higher at the center than at the two ends. This camber is common to railroad bridges of this type to insure proper distribution of the loads when trains are crossing. In this instance, it was found that the old girders used as falsework sagged about ⅝ inch at the center under the weight of the new girders. Hence the new girders had to be given a camber of 1⅞ inches to compensate for this deflection.

The remaining material required for the new girders was partly made up and riveted in the yards. This material was delivered to the up track each day, during a period when traffic was suspended, and lifted across and on to the deck of each new girder by the crane working there. This crane also handled the pieces during their erection on the support beams. When a girder had been erected the crane was run off the span, the camber checked, and, if necessary, corrected. After that the span was completely bolted up and the girder riveted. There was a clearance of only 17 inches between new and old girders at the bottom, so that inside rivets could not be driven until the old girder had been removed.

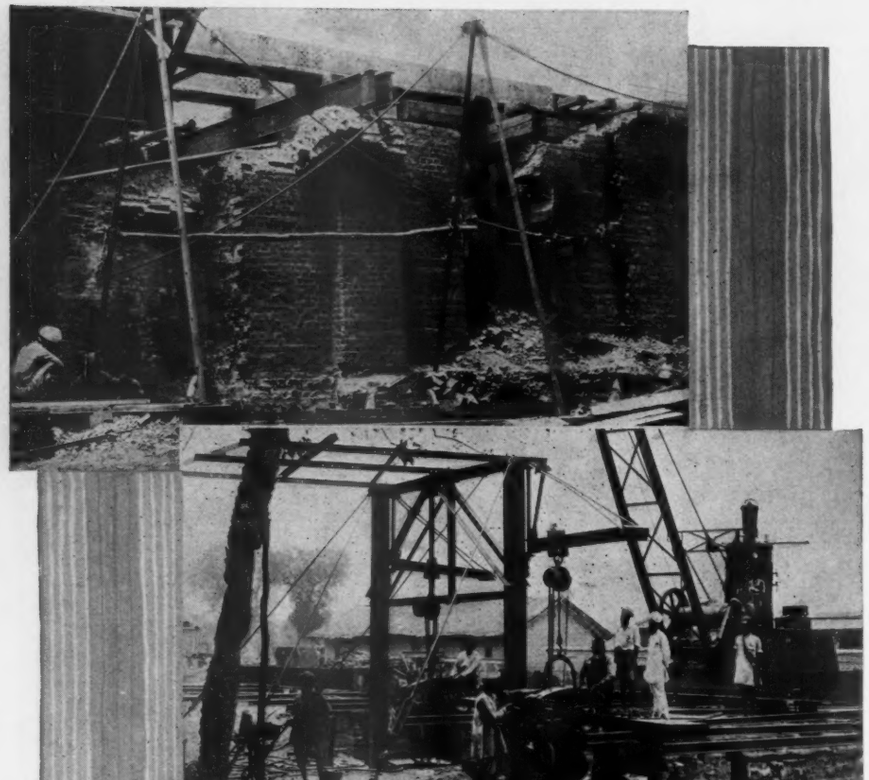
Following the erection of the new girder, a platform was built beneath the old girder to facilitate wrecking operations. This platform was supported on beams slung from the outside of the new girder and inside of the up-track girder. The rivets were removed by pneumatic rivet cutters, and the dismantled material lowered to the platform by either hand tackle or crane. It was then shifted laterally along the platform to the space between the up track and the down track, whence it was loaded by crane into cars on the up track for removal.

The temporary track was next taken up from the deck of the new girder, after which the deck plating was riveted and the wind and sway bracing completed. The deck plating was sand blasted clean and painted with bitumastic paint. The rest of the bridge was painted with red lead. A footpath was provided at the top of the new span and an inspection gangway on the bottom boom.

After eight spans of the new bridge had been thus erected, the approach to the down track from the west side was cut to permit the reconstruction of the abutment. The existing abutment of brick was demolished with CA-35 paving breakers. The new approach span was temporarily supported on timber cribbing to restore access to the down track, and the new abutment was built up under the span. Upon completion of the abutment, the timber cribbing was removed and the approach span lowered to its final position. After the west approach abutment was finished, the approach span at the east end was cut,



1—Riveting new girder which is supported by old girder on the inside. 2—Old girder being lowered into position on new bearings to serve as falsework for the construction of the new girder. 3—Old girder raised and underpinned while new masonry bearings are being laid. 4—New girder viewed from within, showing details of construction. 5—The new bridge as it appeared when nearing completion.



Top—One of the old abutments in partly demolished condition, showing how the approach span was temporarily supported on a pier of cribbing. Bottom—Pneumatic yoke riveters assembling steel parts in the yard adjacent to the bridge.

the abutment rebuilt, and the new approach span erected. It is of interest to note that the old abutments were constructed during the period of the Indian Mutiny in 1857 and in such a way that they could be used as fortifications.

COAL STILL WORLD'S LEADING SOURCE OF ENERGY

THE National Industrial Conference Board has made the announcement that the 15-year period from 1913 to 1928 has been marked by a decided increase in the world production of crude oil, natural gas, and hydro-electric power—the first by 243 per cent, the second by 133 per cent, and the last by 162 per cent. The output of coal, on the other hand, although that fuel is still by far the most important source of energy, was only 5 per cent greater in 1928 than in 1913.

The explanation for this seemingly contradictory state of affairs lies in the fact that it is now possible to obtain much more energy ton for ton of coal than in the years gone. Many contributing factors have helped to bring this about, among them, increased boiler-room efficiency; the recovery of heat from waste gases; the saving of gases in by-product coke ovens; and, last but not least, the creation of great central power stations that have so largely supplanted numerous small and scattered plants that are relatively wasteful of fuel.

IMPROVED BUFFING WHEEL

WHAT is termed the "Quick-As-Wink Buffing System" by C. B. Hunt & Son, of Salem, Ohio, is made possible they say by their new rubber-cushioned buffing wheel which has been produced by them as a substitute for the old rag buffing wheel.

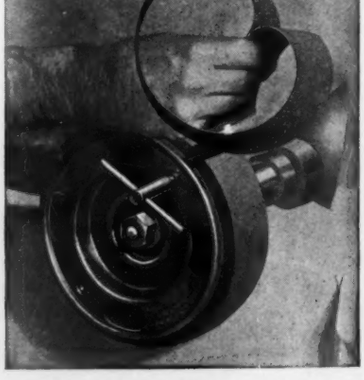
According to the manufacturer, a clean, smooth buffing action is assured the full width of the face of the wheel on either stationary or flexible shaft buffers. Wheels of 6-, 8-, and 12-inch diameter are made; and abrasive cloth of any grade, from 24- to 180-grain, can be used. A new abrasive band can be applied readily without removing the wheel from the spindle, and these strips can be attached with or without metal end clips. After a strip is in place it is tightened by the slight turn of a wrench—the subsequent revolving of the wheel causing the rubber cushion to expand and to hold the cloth securely. Thus the slipping of the band at any speed or pressure is prevented, making for safe operation at all times. Before shipment, each wheel is tested at speeds up to 8,000 revolutions per minute, although speeds ranging from 3,500 to 5,000 revolutions per minute are recommended for most efficient service.

The company is equipped to furnish abrasive cloth strips either with or without metal clips; but for the convenience of large users it has built a combination cutter and clipper capable of turning out 300 bands per hour.

SAND BLAST MAKES OLD GAS PIPES FIT FOR RE-USE

THE Moncton Tramway Electricity & Gas Company, of Moncton, N. B., Canada, is doing some salvage work by the aid of a compressor and a sand-blast outfit that is effecting worth-while savings. To be explicit, they are making old gas pipes fit for re-use. If you have ever watched the service squad of a public-utility company take up gas or water mains, you will have noticed that they are more or less thickly encrusted with dirt, scale, and rust—in other words, they look as though they are good only for the scrap heap. And that is where they not infrequently go. However, many of these pipes still have years of useful life ahead of them provided they can be thoroughly cleaned and reconditioned at a cost that justifies going to that trouble. For trouble it is if the work be done by hand labor. But, as we shall see, the story is quite a different one if the cleaning be done by modern facilities, as is the case in the yard of the Moncton Tramway Electricity & Gas Company.

To this yard are sent all the company's old gas mains as soon as they are taken up; and there most of them are reclaimed in short order and at low cost and put back in stock for re-use. The actual cleaning is done by sand blasting—the air for this purpose being supplied by a 9x8-inch ER-1 compressor that was especially provided for that service. With the metal surfaces thus freed of all caked earth, rust, etc., the pipes are inspected for minor weak spots, which are drilled, tapped, and suitably plugged. After that they are painted—the entire process, from beginning to end, costing 6½ cents per foot. Contrasted with new pipe, at $1.10 a foot, there is no denying that the salvage work is profitable. These figures cover 4-inch pipe. When they have been overhauled, the pipe lengths are graded, according to their condition, as "firsts", "seconds", and "thirds"—as much as 75 per cent of the material so handled, the company's records show, being rated as first-class stock.



Putting a new abrasive band on the rubber-cushioned buffing wheel. After the ends are inserted in the slot, as shown, the hold on them is made tight by a turn of the attached wrench.

Sapphires of Beauty Found in America

Left—Plant of The New Mine Sapphire Syndicate set in the rugged heart of the Rocky Mountains.

Right—An open cut in the neighboring hills that was washed out in search of values about 30 years ago.

SAPPHIRES as blue as cornflowers—the loveliest blue in gems—are found in the Valley of Yogo Creek, about 25 miles to the south and west of Lewistown, Mont. The deposit is tucked away in the very heart of the Rocky Mountains, and fully 5,000 feet above the sea and out of the beaten track of travel. These uniquely beautiful sapphires owe their discovery to an unsuccessful quest for gold years ago.

Rumors that the region was rich in the precious metal drew prospectors to the upper part of the Yogo Valley as early as 1879; and when gold was not forthcoming in encouraging quantities the search generally ceased. But four adventurous men determined to try again and to direct their efforts to the lower watercourses in the valley—believing that time had washed the precious particles down from the mother lode and into the sands and gravels accumulated there over a long, long period. This was in 1894. After the expenditure of many thousands of dollars in equipment and plant, the partners finally had to show for their labors and outlays gold dust to the value of only about $700! Also, as a result of their washing operations, they had a cigar box full of blue crystals—pleasing to the eye but of no monetary significance to those gold hunters. An eminent gem expert of New York City, however, promptly identified them as sapphires, and sapphires of a notably superior sort!

The ore that carries the sapphire crystals fills a nearly vertical fissure in a horizontal series of limestone rocks. The intruded material was once molten igneous rock that forced its way surfaceward from the bowels of the earth. As that plastic mass rose through the superposed limestone it picked up fragments of shale and limestone; and these fragments, by reason of the heat and the pressure then exerted, were transformed into sapphires. That great forces were at work in that crucible of Nature's making is evidenced by the fact that the dike has an average width of 8 feet between the flanking walls and that the limestone formation penetrated is known to be 1,000 feet thick and to rest upon Cambrian shale of nearly the same thickness. In short, the column of igneous rock had to rise not less than half a mile and to crowd itself upward against confining walls that were virtually immovable. Thus the sapphires were born.

The property today is owned by The New Mine Sapphire Syndicate, which has already mined and marketed from that source gems to the value of from $3,000,000 to $4,000,000. The holdings have an area of something like 1,250 acres; and the sapphire lode has a proved length of 3½ miles. The sapphires from the New Mine run a color gamut all the way from deep magenta through various shades of pure blue to the cold glint of steel. When cut by the lapidary, the stones have the unusual quality of being radiant alike in daylight as well as at artificial light; and the color—be what it may—is evenly distributed and quite devoid of the "milkiness" or lines that impair the commercial and the artistic value of sapphires from other parts of the world.

Another open cut made years back that developed little that was worth while to operators.

Because of their evenness of coloring, Montana sapphires can be matched easily; and for this reason alone—if for no other—they surpass in value sapphires originating elsewhere. They are thus more economical to handle from the manufacturing jeweler's point of view. The jeweler buys by the packet, taking stones of different sizes and often of different hues. Uniformity in color is, therefore, an advantage whenever the stones are to be set in one piece of jewelry and must match.

The material in which the sapphires occur varies in appearance and in character from a hard rock down to a soft, yellow, oxidized clay. In fact, the rock will decompose into clay if exposed to the weather and washed vigorously with water from time to time. Most of the profitable ore or rock has been mined in drifts driven at a depth somewhere around 250 feet below the surface; and this work has been done with air-driven rock drills such as Ingersoll-Rand drifters, stopers, and "Jackhamers". The practice has been to break the ground with a low-power nitro-explosive so as to injure as little as possible the sapphire crystals.

When first brought to the surface the ore is generally hard and fairly compact, slightly blue in color and tinged with green. The green shade is due to the presence of minute particles of yellow pyrites. The sapphire crystals are distributed sparsely throughout the ore; and weathering and washing opera-

tions on a large scale are needed to effect the extraction of the gem stones. Washing operations are possible only during the open season between May and November; but underground work can be done the year round. The approved procedure, as it has been developed by The New Mine Sapphire Syndicate since it began opening up the property back in the "nineties", is as follows: The ore is loaded into cars in the mine—each car having a capacity of 18 cubic feet; and on reaching the surface the ore is run out from the pit head and dumped so as to form large heaps in the course of months. These are built up on wooden floors to facilitate washing operations—the total area of the floors being considerably more than 100,000 square feet.

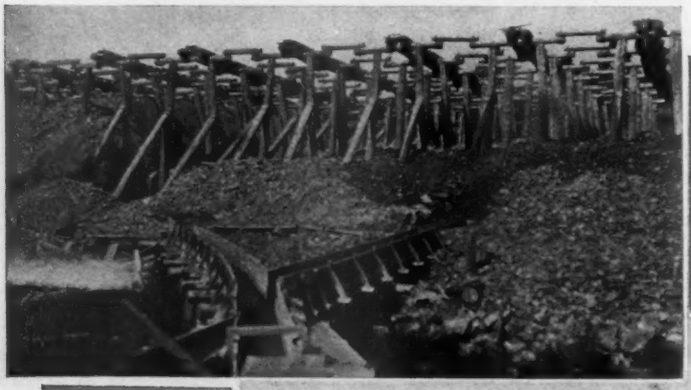
preparatory to rewashing. Ultimately, the accumulation in this dam is sluiced out over riffles. Any large pieces of ore that still resist decomposition are again collected in a second dam.

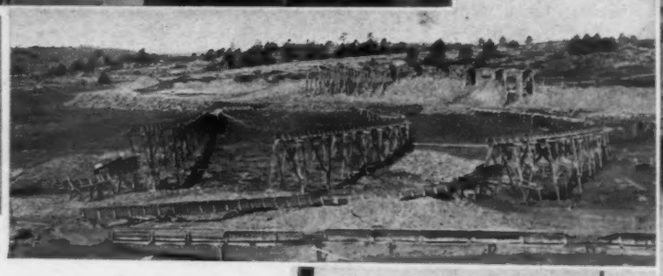
The rock exposed to weathering in the second dam is sluiced over a second series of riffles leading to a third dam; and from time to time the third dam is sluiced out and the tailings are permitted to flow to a waste dump. All told, the operations, as outlined, spread over four seasons. In other words, from the day a given carload of ore is deposited on the dump until it is finally disintegrated and the last of the sapphires recovered a period of well-nigh four years may elapse.

Sluicing may be suspended four or five

coloring, are put to industrial and scientific services. They are used to manufacture bearings and jewel-holes for watches, clocks, chronometers, and for other delicate machinery and apparatus. Sapphires have been used in sound-reproducing machines. The larger crystals are sold in the rough or go to lapidaries who cut them into the forms suitable for mounting by jewelers.

The property of the syndicate is capable of extensive development; and this will probably be done as older foreign sources of sapphires become exhausted. Indeed, the Montana deposit is quite capable of providing the whole world with sapphires for years to come. The finest of the blue "New Mine" sapphires have brought as much as $1,600. These gems





Left—In the foreground are flumes, conveying water from Yogo Creek, with trestles and tracks at the rear to facilitate distributing the ore for weathering.

Right—Washing floor with piles of slacked and unslacked ore.

Center—General view of one of the several washing floors.

Bottom—Compressor house containing two Ingersoll-Rand machines that furnish air to operate rock drills and a No. 33 sharpener.

After being exposed for some while, the weather will cause the ore to break up or slack. When this has progressed far enough the ore is sprinkled at frequent intervals with water; and this hastens the disintegrating process which aids in the ultimate extraction of the sapphire crystals. The necessary water is obtained from Yogo Creek and conveyed by a long flume to the site of the recovery operations. The washing serves to carry the pay dirt into a series of sluice boxes. Across the bottoms of these boxes there are iron riffles placed so as to catch the sapphire crystals, which have a high specific gravity. At the same time the lighter mud and gravel and undisintegrated pay dirt are run into a dam where they undergo further weathering

times during each 24 hours, and at those stages the riffles are lifted and the concentrates cleared and washed in hand rockers. A rocker consists of a series of shallow sieves fitted with graduated screens that pick out the crystals and mechanically assort them roughly according to their sizes. The larger-sized concentrates are usually hand sorted at the mine, but the gem crystals are sent elsewhere for grading and cutting. The finer concentrates are dealt with by a separating machine. This apparatus operates so as to throw any gravel to one side while incidentally dropping the small marketable bits of sapphire into a collecting trough. Most of these small crystals, because of their size and also often because of their less desirable

must not be confused with the blue-green, yellow, pink, and white varieties of corundum that are commonly of but little commercial value. For the sake of those unfamiliar with the fact, the sapphire belongs to the corundum group, which is a crystallized sesquioxide of aluminum. This corundum group also embraces the ruby.

While "New Mine" sapphires have long sold for less than sapphires originating in the Orient, they have done so simply because the wealth of the deposit and the relative ease with which they could be extracted made this feasible. But the lower price has not meant that the sapphires were not the equal of the best from other sources—as a matter of fact, the loveliest of them are unrivaled in richness of coloring and in brilliancy.

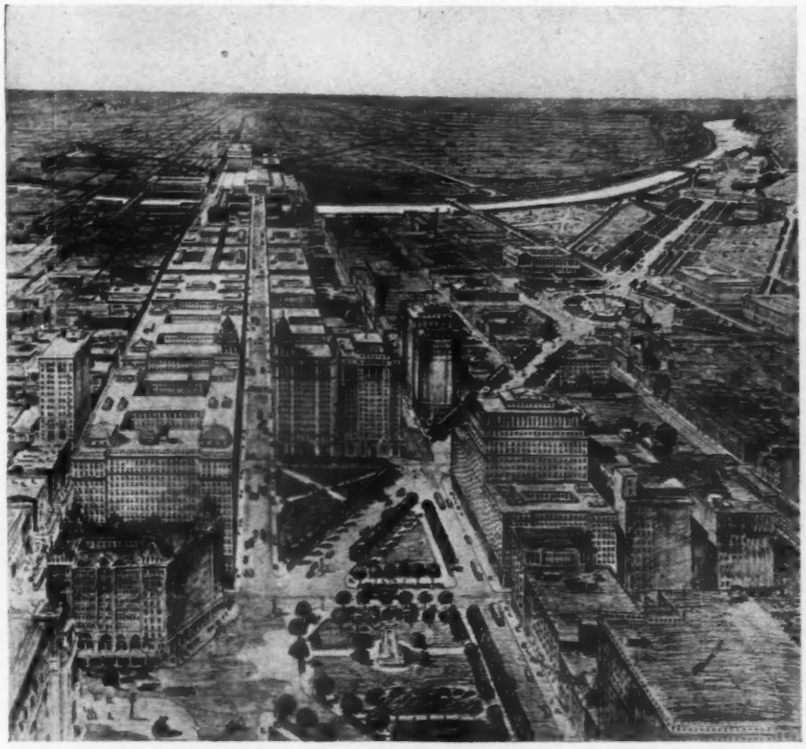
Pennsylvania Railroad Building New Terminal in Philadelphia

This Magnificent Undertaking Is an Integral Part of the Extensive Electrification of the Company's Lines on Several Divisions

By R. G. SKERRETT

WHO could have envisioned the development of The Pennsylvania Railroad since its charter was granted in 1846? The changes that have been made in the meanwhile have been great and varied, and today other changes are in hand in the name of betterment that are nothing less than revolutionary in their nature and their scope—each and all of them primarily for the comfort and convenience of the traveling public.

The Pennsylvania Railroad was organized to help to insure Philadelphia a commensurate share of the commerce with the then new West that had Pittsburgh as a gateway. How well the road has served Philadelphia is a matter of historical record that is both highly creditable to the trunk line and extremely gratifying to all concerned. In the course of the intervening 84 years the railroad has grown from what might be called a local enterprise into an institution of national significance—serving well and impartially every community lying along its far-flung lines.



Looking west from Broad Street Station to the new station to be reared near the Schuylkill River. The intervening modern buildings show how the old viaduct area will be used.

In the expansion of its field of service, The Pennsylvania Railroad created about 50 years ago its central passenger station at the intersection of Broad and Market Streets in the very heart of Philadelphia. The location was a wise one—being close to the retail shopping district and near the principal hotels and places of amusement. At that time the majority of the citizenry of Philadelphia lived between the Delaware River on the east and the Schuylkill River on the west. For years the Broad Street Station met every requirement easily; but eventually increased traffic made the handling of trains and people a difficult and even a complex problem. This is understandable when one learns that there is now an average daily movement in and out of Broad Street Station of about 380 trains, and in 24 hours the traffic involves ordinarily the carriage of 65,000 persons. Various conditions and circumstances emphasized the desirability of a change that would entail the abandonment of the old station and the creation of a new one elsewhere within the city limits.

In railroad parlance, Broad Street Station is termed a stub-end terminal. It is now located off the natural routes of through traffic, and it entails costly cumulative expenditures in moving trains into the station and then reversing their course when sending them onward. Trains entering and leaving Broad Street Station do so over a viaduct that extends westward all the way to the Schuylkill River and right through a densely built-up section of the city. This viaduct, frequently referred to as the "Chinese Wall", flanks one of Philadelphia's most important business streets; and the structure has unquestionably hampered intercourse north and south and has interfered with the development of neighboring property in latter years.

While the viaduct is wide enough to accommodate sixteen parallel lines of track over most of its length, still there are sections of this elevated route where only six tracks are available for continuous service. This constitutes a bottle neck that seriously obstructs train movements during daily recurrent peak periods. The wonder is that the railroad has so long functioned as splendidly as it has via the Broad Street Station. Since the station was built the city's center of population has shifted, and West Philadelphia—not so long ago but sparsely settled—is now an extensive and densely populated part of the municipality. Not only that, but a section of West Philadelphia on the west bank of the Schuylkill River lies just where a great central passenger station could be reared that would best serve the interests of Philadelphia as a whole and at the same time accommodate trains passing through the city and bound north, south, east, and west.

Accordingly, the railroad authorities, after much study, decided to erect their new central station in West Philadelphia near the river and almost due west of the Broad Street Station. The new terminal will be near where the road has long maintained a subordinate transfer station. Within the chosen area tracks are now being so arranged that they will make it possible for through trains to stop in order to take on or to discharge passengers and then to proceed without engine change and without reversing the direction of advance—thus saving considerable time and reducing incidentally the number of essential operations. The turn-round of certain of the through trains will be facilitated by loop tracks.

As explained by one of the engineering staff of The Pennsylvania Railroad, "The loop, so-called, is an inexpensive but most essential part of the new terminal plan; in fact that loop, more than any other consideration, determined the location of the new Philadelphia Station on the Schuylkill. Today, we cannot route New York-Western trains to West Philadelphia and Broad Street Station except by changing power, reversing sets, and sending trains out the

same way they came in. These loop tracks, which are on nearly a level grade and with a curvature of 9°, the same as the curvature on the Horse Shoe Curve on the eastern slope of the Allegheny Mountains, will permit a train from New York to the West, and *vice versa*, to make a continuous movement over the route through West Philadelphia Station". Provision will be made in the station for sixteen through tracks, each with 1,500-foot platforms, and there will be six additional tracks and platforms for the accommodation of suburban traffic—making a total of 22 tracks.

Blacksmith shop that conditioned all the drill steels used by the United Engineers & Constructors, Inc., when excavating the cut for the West Philadelphia Terminal.

The West Philadelphia Station, when finished, will be up to date in every particular, embodying every improvement and every convenience which long experience has revealed to be desirable. There will be two track levels—the lower one serving through and other long-distance trains, while the upper level will be used by suburban trains. The latter will have their terminal at a new underground station that will be located north of the present Broad Street Station and one block westward. The trains will cross the Schuylkill River by a handsome new bridge; and, inasmuch as the trains will be driven by electricity and composed of multiple-unit cars, it will be necessary only to reverse the seats and for the engineer to shift his position from one end of the train to the other to have a train ready for its outbound run.

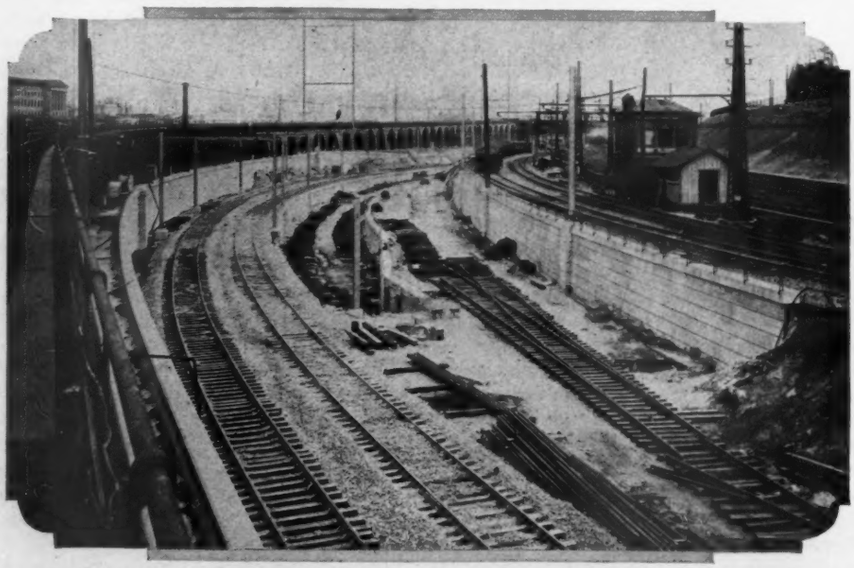
The improved and greatly amplified terminal facilities in Philadelphia form but part of a very extensive program of electrification which is destined to revolutionize the entire passenger and freight service of the railroad throughout the densely populated territory served by the Pennsylvania system and extending from Hell Gate Bridge, N. Y., to Washington, D. C., and from tidewater to points inland on the Susquehanna River. Philadelphia, as heretofore, will continue to be the focal point of the area to be electrified. The completion of this magnificent undertaking will give The Pennsylvania Railroad a total of 799 miles of electrified line embracing 2,759 miles of track.

Gen. W. W. Atterbury, president of The Pennsylvania Railroad, has said: "This electrification will far exceed in magnitude and in importance that of any other railroad in the world in miles of track to be electrified, in volume and density of passenger and freight business handled, in size and amount of equipment required, in the number of trains affected, and in terminal operations involved." Electrification and the terminal improvements in Philadelphia will cost a vast sum, and is being spent for the primary benefit of passengers and shippers. The engineers of the railroad have looked forward to potential conditions years ahead.

The system adopted will be capable, by the simple addition of increased power and increased rolling stock, of handling throughout the electrified area a movement of any magnitude that may be maintained over existing tracks and at such speed—within the bounds necessary for safe operation—as the demands of traffic may call for from time to time. The engineers kept before them the possibility that the metropolitan area around New York City would include New Brunswick, N. J., by 1950 and, with the contiguous section of Long Island on the east, would then contain 30,000,000 people. It was also borne in mind that kindred growths were likely to occur in other cities served by the electrified system.

With the new West Philadelphia Station completed and the suburban-service terminal operating at 16th Street, then the old viaduct or "Chinese Wall" will be razed, and upon the property thus made available for development there will rise business and office structures of thoroughly modern types that will net the municipality annually additional revenue amounting to about $2,000,000. The demolition of the viaduct will permit the construction of a broad and beautiful boulevard paralleling Market Street and terminating at the imposing structure of the new central passenger station.

In preparing the terminal area for the new tracks it has been necessary to clear away and to change the grade of certain property lying between an elevated freight viaduct on the east and the lines of tracks on the west used by passenger trains approaching the West Philadelphia Station from north, south, east, and west. The area in question has a length of approximately 3,000 feet and a width of 150 feet; and the change in grade called for a cut varying from 1 foot to 25 feet in depth. This work was awarded the United Engineers & Constructors, Inc., who started operations on August 27, 1929, and completed it early in April of the current year. The task involved the excavating and removal of substantially 130,000 cubic yards of earth and rock—55,000 cubic yards of that total being rock consisting for the most part of a granitic and mica-schist formation that proved to be very tough and difficult to break.

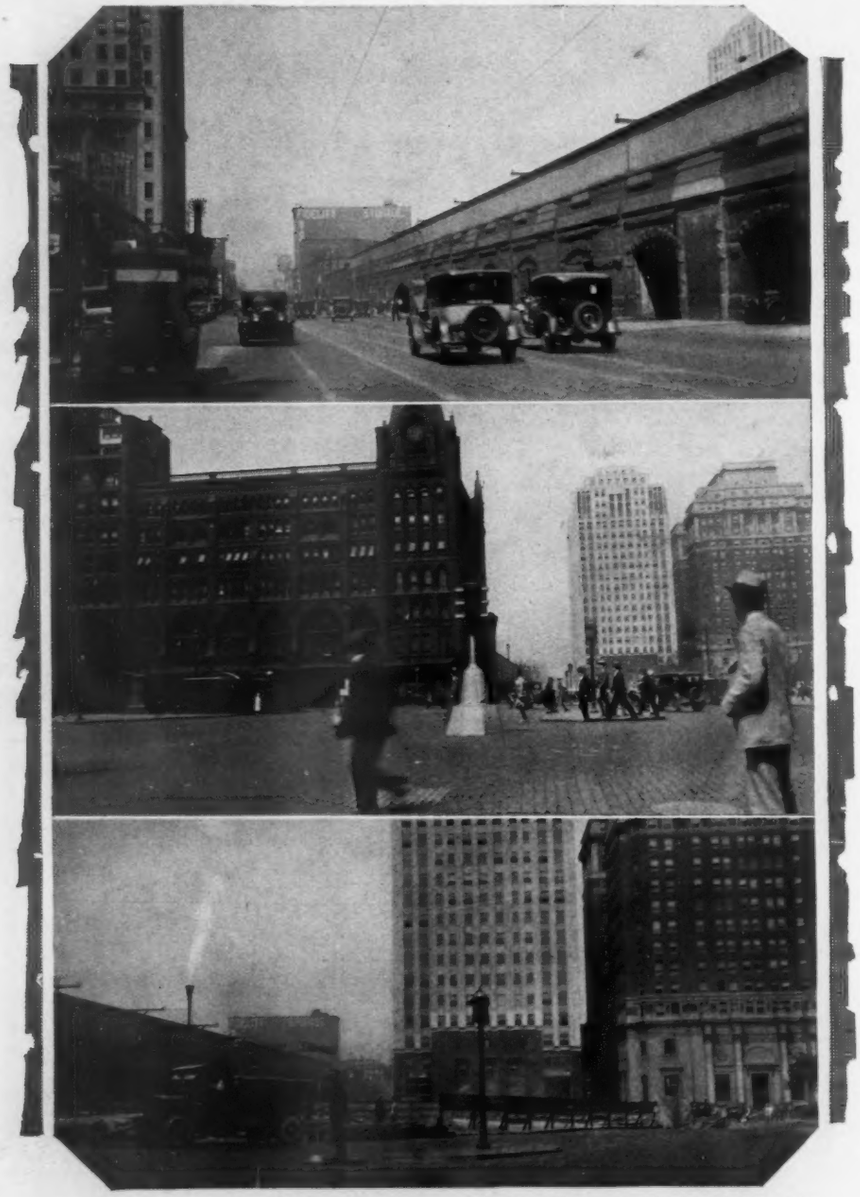


How the cut made by the United Engineers & Constructors, Inc., appeared when finished.

Owing to the fact that trains were passing nearby at frequent intervals, and by reason of overhead power lines being close to the cut, great care had to be exercised in blasting. There were occasions when blasting was held up

1—Group of S-49 "Jackhamers" drilling a line of holes in the cut excavated by the United Engineers & Constructors, Inc. 2—How the work looked on a wintry day at the end of January of the current year. 3—One of the several Erie-Bucyrus steam shovels employed in handling broken rock after a blast in the West Philadelphia Terminal cut. 4—Link-Belt derrick utilized in handling forms and pouring concrete during the building of retaining walls flanking the West Philadelphia Terminal cut. 5—Erecting forms and placing reinforcing steel preparatory to pouring a concrete retaining wall at the base of the freight viaduct flanking the east side of the cut.

from one to three hours in the course of a day because of train movements; and every blast was made beneath a covering of heavy rope mats weighed down with ties. These had to be arranged properly to effectually prevent any of the rock scattering. The rock resisted fracture, and not infrequently broke into pieces 10 to 15 feet in length and from 5 to 6 feet in cross section. This necessitated much block-holing in order that the rock could be attacked successfully with power shovels. Ordinary rock will break readily when hit by a power shovel, but the granite in the Philadelphia cut would not do so. Besides excavating and walling in the cut, the contractor was called upon to underpin a bridge at the southern end of the job so as to carry the excavation to the prescribed depth.



Top—Looking west on Market Street with the "Chinese Wall" flanking it on the north. Center—Northeast corner of the Broad Street Station. Bottom—Excavation at 16th Street for the new underground suburban terminal.

The excavating for the new track arrangement had to be done speedily even though much of the job entailed working during the winter season. Therefore, the contractor so organized his force and so equipped himself that much could be achieved despite the time limit and the likelihood of much bad weather. The contractors had at their disposal a sufficient number of S-49 "Jackhamers" of the blower type, and these did all the rock drilling. In addition to those tools they had CC-45 paving breakers which were utilized to drive wooden sheet piling and to chip outstanding irregularities on the face of blasted rock. The piling was used in constructing forms for pouring concrete retaining walls and the concrete walls of ducts for telegraph and telephone cables. It was 3x10 inches in cross section and ranged from 16 to 20 feet in length, and was required for a total distance of 1,500 feet.

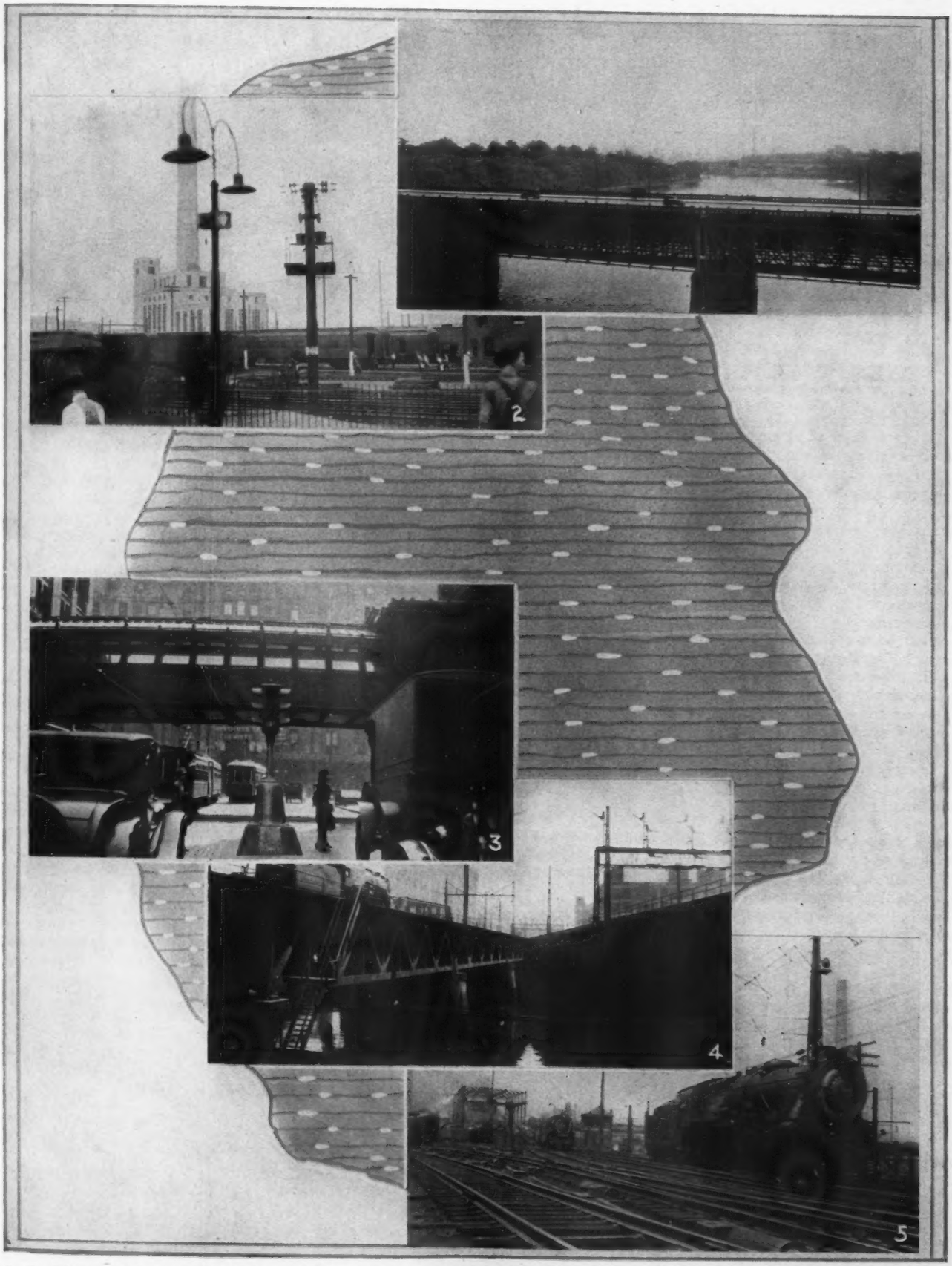
The rock was drilled with 1-inch hollow hexagon I-R Swedish steel in lengths varying from 2 feet to 14 feet and with 2-foot changes. At the start, the drill runners were permitted to exercise their own judgment as to the number of times a bit could be used before going back to the blacksmith shop for reconditioning; and while this practice prevailed the breakage was somewhat high. Then the superintendent made it a rule that no bit could be utilized more than once before being returned to the blacksmith shop. The change cut down the total daily steel breakage from 42 to 7; and the day the new rule went into force there was a gain in footage of 563 feet! Indeed, this rule virtually eliminated drill-steel breakage. The following figures, taken at random from drilling records, show plainly what the men were able to do under skillful direction:

Drilling Days	Total Footage per Man	Average Daily Footage per Man
21	3,865	184
23	3,647	159
24	4,620	192
25	4,256	170
25	5,432	217

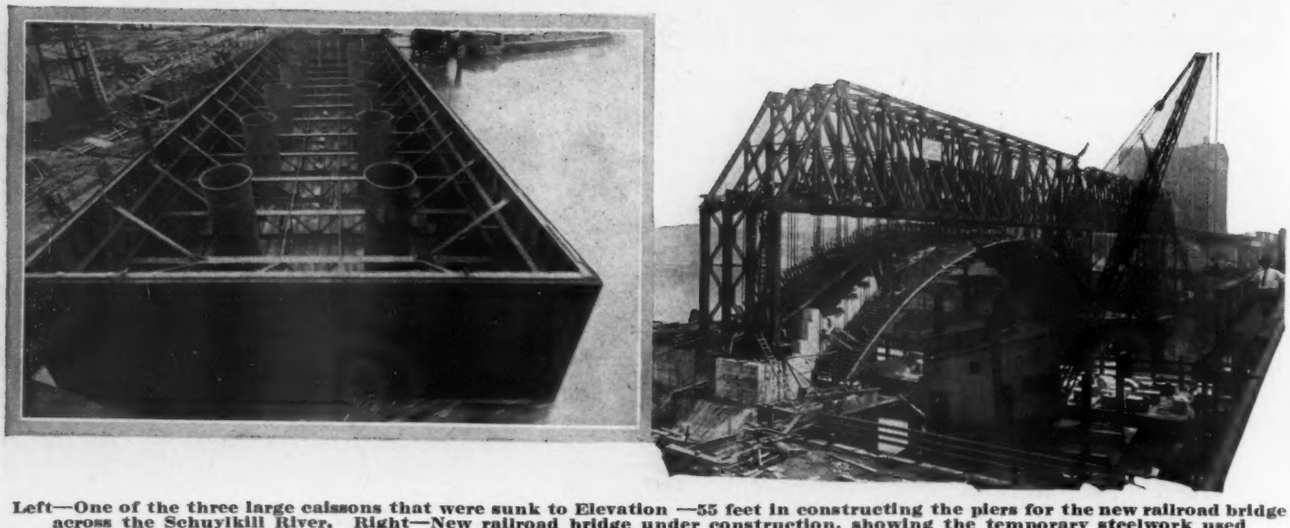
The contractors equipped their blacksmith shop with a No. 34 Ingersoll-Rand sharpener and a No. 5-F oil furnace. In the course of a 9-hour day the shop was called upon to recondition from 500 to 600 steels. The practice was to have an ample quantity of steel available so as to work up aplenty of it before changing dies. This assured a steady supply to the drill runners and it also saved much time and money. The blacksmith shop was provided with six tubs of water, and this made it certain that there would always be at hand several at the right temperature to quench the steels even though some of the tubs of water would be too hot for that purpose. The blacksmith shop had a force of four men; and the oil furnace was so arranged that the blacksmiths could get double service out of it. These operating details are mentioned because of their practical value and likewise they may help others having kindred work to do.

While this article has to do primarily with the new terminal facilities that The Pennsylvania Railroad is calling into being in Philadelphia, still it should be a matter of general interest to know what this enterprising and public-spirited system plans to do in Baltimore as part of the broad scheme of electrification and service improvement. After some years of negotiation, the municipal authorities of Baltimore and the officials of The Pennsylvania Railroad have agreed to the project now in hand.

The undertaking embraces, among other things, the electrification of the existing tunnels in Baltimore, which will add much to the comfort of persons using the road. In addition to that, the capacity of both passenger and freight lines will be greatly increased. One of the two new double-track tunnels to be constructed in Baltimore will parallel the existing Union Railroad tunnel east of the Pennsylvania Station. It will



1—Looking south on the Schuylkill River from the Pennsylvania railroad bridge over which trains pass between New York and Philadelphia. 2—Present train yard as seen from a car window at the West Philadelphia Station. 3—Intersection at Market and 15th streets showing bridge linking the Broad Street Station with the neighboring Commercial Trust Building. 4—Bridges across the Schuylkill River that carry railroad tracks converging upon the Broad Street Station. 5—Steam locomotives in the present yard at West Philadelphia.



Left—One of the three large caissons that were sunk to Elevation —55 feet in constructing the piers for the new railroad bridge across the Schuylkill River. Right—New railroad bridge under construction, showing the temporary steelwork used to sustain the forms required during building. This reversed the usual procedure and left the waterway clear for traffic.

extend for a distance of about two-thirds of a mile, the length of the present tunnel. The other one will approximately parallel the Philadelphia, Baltimore & Washington tunnel; it will have a length of about 1⅝ miles, as compared with the 1½ miles of the much used old tunnel; will run at an average depth of 80 feet below the street level; and will have to be driven through rock instead of being constructed by the open-cut method.

The new tunnels will permit The Pennsylvania Railroad to operate a 4-track main line all the way through the city from the eastern to the southwestern boundary—a stretch of six miles—with ample clearance for the largest and heaviest cars and locomotives, as well as for unusual sized shipments such as turbines, generators, and other large machines transported in special cars. All grade crossings will be eliminated.

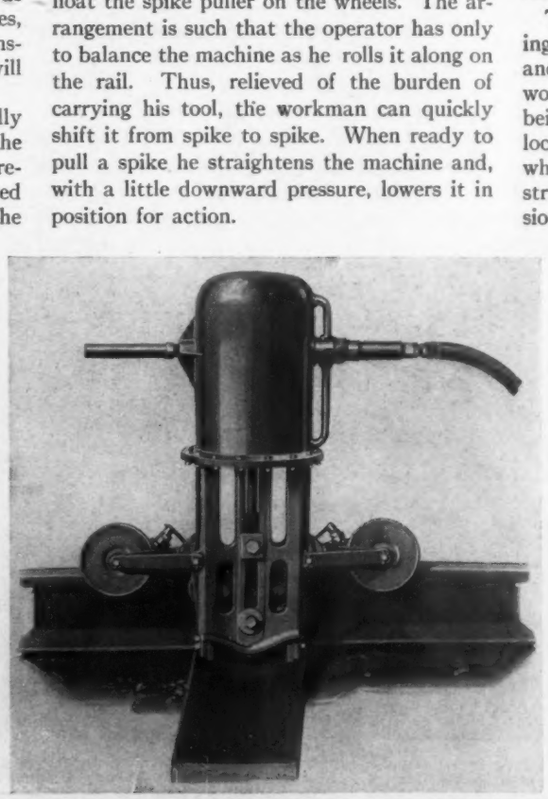
Two large freight warehouses, centrally located, will be constructed adjacent to the existing Calvert Station, which will be rebuilt. Between five and six years are allowed in the agreement for the completion of the tunnel work, the new station, the freight warehouses, the grade crossings, and the electrification. The expectation is that the electrification of the road between New York and Wilmington will have been finished before the expiration of that period. The whole program is one of splendid proportions; and its primary purpose is to enable the road to serve the public just that much better. A fine example of foresight and progressiveness.

What is probably the longest underground mine level in the world is fast nearing completion on the Witwatersrand. It is the seventh level and the third level, respectively, of the Geduld Proprietary and the East Geduld gold mines, and lies at an approximate depth of 2,500 feet. It will have a total length of not less than 28,000 feet or 5⅓ miles.

PNEUMATIC SPIKE PULLER ON WHEELS

A PNEUMATIC spike puller that is mounted on a rail carriage so as to facilitate handling is among the equipment lately produced by the Ingersoll-Rand Company of New York, N. Y. This machine is known as the SP-9. It is fast and positive in its action and, except for the carriage, does not differ much from the company's earlier model.

The carriage, as can be seen, consists of two rail wheels fastened to brackets which are hinged to the frame; and an adjustable spring furnishes sufficient downward pressure to float the spike puller on the wheels. The arrangement is such that the operator has only to balance the machine as he rolls it along on the rail. Thus, relieved of the burden of carrying his tool, the workman can quickly shift it from spike to spike. When ready to pull a spike he straightens the machine and, with a little downward pressure, lowers it in position for action.



The new Ingersoll-Rand air-operated spike puller mounted on wheels to facilitate shifting.

TESTING PROTECTIVE COATINGS FOR PIPE LINES

IN view of the vast network of underground pipe lines built and building in the United States for the transmission of petroleum and gas from oil fields to refineries and thence to consuming centers, a series of exhaustive experiments now being conducted jointly by the United States Bureau of Standards and the American Petroleum Institute should be of interest generally to pipe-line operators. The experiments have to do with the coating of these transportation arteries in an effort to determine the effect of different soils on different compounds used for this purpose.

Twenty kinds of standard protective coatings—including greases, emulsions, enamels, and bituminous materials reinforced with woven fabrics or covered with metals—are being applied to working oil lines in fifteen localities chosen for their soil characteristics, which range all the way from extremely destructive to mildly destructive ones. Provisions have also been made for the testing on short lengths of pipe buried alongside these working lines of as many other coatings as the manufacturers cared to submit. These short lengths were laid at the same time the pipe-line sections were treated so that all conditions might be equal. As the oil and gas industry of the United States maintains something like 100,000 miles of pipe lines, the significance of these experiments, designed primarily to counteract corrosion, can be appreciated.

Aluminum gas pipes are being used in increasing measure in German homes because, report has it, they can be readily bent by hand and closely fitted to the walls. The comparatively high price of that metal is said to be more than offset by the ease with which the pipes can be installed and by their attractive appearance.

Air-Driven Saw Does Good Work Cutting Piles Underwater

By B. G. CROSS

DUE to the growth of Vancouver, B. C., both south and west of False Creek, and so as to protect the city's famous bathing beach at English Bay as well as the industrial section lying within the False Creek area, the Vancouver and District Joint Sewerage and Drainage Board decided to divert the increasing volume of sewage from the territory mentioned by leading it into a single main outfall at the foot of Imperial Avenue. Under the present plan, the outfall is to be carried offshore underwater for a distance of 3,000 feet; and there is a possibility that this conduit will eventually have a length of 5,000 feet. The new sewer line, when completed, will reach inland for about five miles.

Work on the project was started in June of 1929; and the tunneling and the trenching have since advanced at a commendable rate. The tunnel has a 9x6-foot section, and is being driven at an average depth of 45 feet below the ground level. Through the residential section of the city, however, it will be at a depth of about 100 feet. Shafts, at suitable intervals, are sunk to intersect the tunnel line so as to facilitate operations in each direction from those points of attack. The crews work continually in three shifts daily, each of 8 hours' duration. The tunnel penetrates a formation of hard sandstone and shale, and is being driven with light drifters—among them being a number of L-74's. Owing to the fact that the rock disintegrates rapidly when exposed to the air, it is necessary to timber both the shafts and the tunnel.

As the tunnel is advanced it is lined with concrete shot in place with compressed air. Three compressors supply the air for this purpose and to operate the rock drills. Two of these are ER-2 Canadian Ingersoll-Rand belt-driven machines. Muck from the tunnel is loaded into ore buckets placed on flat cars and pushed to the shafts, where it is hoisted and automatically dumped into portable bins that are later removed by motor trucks. When the tunnel is completed the shafts will serve as means of getting into the sewer for inspection or for the making of repairs.

The outfall section of the sewer is formed of concrete pipe 5 feet 6 inches in diameter. Each unit is 8 feet long and weighs about 7½ tons. The line is being laid at a maximum depth of 75 feet underwater. For this purpose, a 12x10-foot trench is being excavated by a dredge. In this trench is driven a double row of piles 9 feet apart laterally and spaced 6 feet apart longitudinally. These piles are then sawed off in line just clear of the bottom of the trench, and 10x12-inch timber cross caps are spiked successively to each pair of flanking piles. The cross caps are weighted and lowered into place; and the ⅞-inch drift pins used to secure them to the tops of the sawed-off piles are driven by divers using heavy hand hammers. The drift pins are about 15 inches long.

When the piles have been sawed off and the cross caps spiked to them, then the concrete pipe sections are lowered on to this foundation and assembled. While the weight of the pipe units is ample to keep them resting firmly on the cross caps, still it is deemed advisable to steady them against any lateral thrust that might be induced by tidal currents. Therefore, steel rails are being laid longitudinally on the cross caps—a line of them on each side of the pipe, to effectually anchor the outfall to the underlying supporting timbers.

To cut the piles off underwater the divers use a portable Wolf saw driven by an Ingersoll-Rand air motor. It takes on an average of from 1½ to 2 minutes to saw through the fir piles which range between 12 and 15 inches in diameter. When at a depth of 65 feet, for example, the saw operates satisfactorily with air at a pressure of from 80 to 90 pounds. Before resorting to the pneumatic saw, it took a diver—working at a depth of from 55 to 60 feet, substantially 45 minutes to cut a single pile with a crosscut hand saw.

The exhaust air from the saw is not piped to the surface but is led away through 1¼-inch rubber hose so as not to agitate the water at the saw and thus to impede the work of the divers. This exhaust line is approximately 75 feet in length and ½ inch greater in diameter than the hose delivering motive air to the saw. It is possible, of course, to pipe the exhaust from the saw to the surface, and this would be done if hydrostatic conditions made that desirable.

Owing to the effectiveness and the economy of the air-driven saw, a spare one is held ready in case of need. Experience has revealed that the saw can be kept thoroughly fit for the exacting service expected of it by cleaning and lubricating after each underwater shift and by sharpening the teeth at fairly regular intervals. The need of this is understandable, because sand, mud, and marine growths adhere to the piles.

The estimated cost of the interceptor sewer is placed at $1,750,000. The work is carried out under the supervision of E. A. Cleveland, chairman of the Vancouver and District Joint Sewerage and Drainage Board, and J. M. Begg, chief engineer. They are ably assisted by G. Gilbert, field engineer, and A. H. Mole, superintendent of construction.

London news dispatches have it that the British Government has appointed a committee to report on the possibilities of a scheme to electrify its trunk-railway system as an aid in relieving unemployment.

Left—Divers with an air-operated Wolf saw making ready to submerge.
Right—Sawed-off section of a submerged pile emerging forcibly on reaching the surface.

NEW PROCESS REDUCES COST OF HELIUM

HELIUM at $35 per 1,000 cubic feet! This seems hardly credible when it is recalled that but fourteen years ago 1 cubic foot of that non-inflammable gas cost 50 times as much—that is, $1,700. This comparison gives us a good idea of what has been accomplished in the United States in the meantime in cutting down the price of helium until it is now close to that of hydrogen, which is inflammable and therefore far less desirable for airship use. This achievement is especially significant at this time in view of the fact that construction has been begun on the first of the two great Zeppelins contracted for by the United States Navy. The *Akron*, as the dirigible is to be named, will have a capacity of 6,500,000 cubic feet.

The present reduction in cost has been made possible, according to an official of the Helium Company, of Louisville, Ky., through the development of a highly efficient separation column by means of which helium-bearing natural gas is made to yield that valuable constituent in but one operating cycle in contrast to the two heretofore necessary in order to produce helium of the desired purity. The company in question has two plants with a combined capacity of 12,000,000 cubic feet of helium annually.

RESEARCH CHEMIST POINTS WAY TO USE BY-PRODUCT

GRADUALLY the research chemist is putting by-products to use and, to that extent, helping to lower production costs. One of the latest instances of this kind has been reported by the Rochester Gas & Electric Corporation, in whose laboratory a hitherto worthless by-product in the manufacture of coal gas has been made to yield a hard substance that is said to be superior to bakelite.

In describing this new material, Mr. A. M. Beebee, general superintendent of the company's gas department, said: "It is equal to bakelite in machining and molding qualities and in dielectric strength. It is more resistant to acids and alkalies and stronger at higher temperatures. It is non-inflammable; can be given any desired color or be made transparent; and will pass ultra-violet rays." The product, which has not yet been named, is made by adding formaldehyde to thiourea.

A liquid compound has been developed by a Swiss chemist that, if added in the proportion of 1 to 12 to 15 parts of the water used in mixing Portland cement, concrete, and mortar, is said to accelerate the setting time of those building materials and also to make them substantially impervious to water. The claim is made that the addition of the compound will waterproof the materials so effectually as to stop leakage even under a considerable head. So far, "Sika", as the product is named, has been used principally in Great Britain in waterproofing and arresting leakage in basement walls and floors of buildings, in tunnels and shaft linings, in retaining walls, etc., etc.

THE PRINCIPLES OF COAL PROPERTY VALUATION, by A. W. Hesse. A book of 183 pages, published by John Wiley & Sons, Inc., New York City. Price, $3.00.

AS a consequence of the World War, coal-mining operations in the United States expanded rapidly and greatly beyond the normal proportions of the industry. An outcome of this state of affairs was the subsequent failure of some of these enterprises as well as the absorption of a goodly number of these properties, entailing their examination and valuation. As the author says: "So long as there are coal properties and coal-mining plants, there will be examinations and re-examinations, appraisals and valuations." The purpose of the book is to assist the qualified expert in making such valuations from time to time; and it has been written with this thought in mind and with a careful exclusion of all unnecessary matter.

SKY HIGH, THE STORY OF AVIATION, by Eric Hodgins and F. Alexander Magoun. An illustrated work of 337 pages, published by Little, Brown & Company, Boston, Mass. Price, $2.50.

MAN'S study of flight, that is, his earliest efforts to produce a model that could mount aloft, is attributed to one Archytas, a learned man of Taranto, who lived about 2,400 years ago. We are aware that many centuries elapsed before a balloon was built capable of lifting a human being; and it is common knowledge that it was not until within our own time that man succeeded in getting off the ground in a heavier-than-air machine. The present book describes in an informative and an interesting way just how mechanical flight has been mastered in its essential stages. The book is easy to read; and it tells most of us things with which we are unfamiliar—things that will make us more appreciative when next we see a dirigible or an airplane maneuvering confidently overhead.

TOWARD CIVILIZATION, edited by Charles A. Beard. A book of 307 pages, published by Longmans, Green & Company, New York City. Price, $3.00.

CIVILIZATION! What is it? Opinions differ as to what the term embraces and what it really indicates. There are those that rail and rant against what we in America conceive civilization to be, gaged by our standards of life and the material evidences of our progress as a people. We have been reminded more or less frequently that our civilization is not one of outstanding culture but rather one resting ultimately upon the practical applications of science and machinery. Therefore, the present work is interesting because it is the expression of the opinions of citizens conspicuous in our scientific, our engineering, and our social organization.

According to the dictionary, civilization is a state of social culture characterized by relative progress in the arts, science, and statecraft. And these subdivisions of the broad field of human effort can easily be made to include every line of endeavor. Such being the case, the group that has made the present book possible reveals convincingly that, as a class, each is mindful of his contribution to progress and equally heedful of its potential effects upon his fellow citizens in the years to come. One and all of them are desirous of advancing human welfare; and science and machinery can do this, but they will inevitably compel readjustments in order that the material gains shall be distributed generally and wholesomely. Under wise guidance, civilization, as expressed by progress in America, can and should reach a cultural state heretofore unattained by any other people as a whole, because culture, in the last analysis, calls for leisure, and leisure, in its turn, is usually a reflex of prosperity.

PRACTICAL JAPANNING AND ENAMELING, by William J. Miskella, M. E. An illustrated book of 256 pages, published by Finishing Research Laboratories, Inc., Chicago, Ill. Price, $3.50.

THIS book is the third volume published by the Finishing Research Laboratories, Inc., having to do with practical finishing, and, like its predecessors, is the result of much special knowledge and comprehensive research. It is intended to help those engaged in modern metal-finishing; and the scope of application and service is an extremely wide and varied one. The book contains a wealth of authoritative data and should be of value to many people and concerns.

THE NEW PUBLIC SPEAKING, by Richard C. Borden and Alvin C. Busse, associate professors of English and public speaking, New York University. A book of 155 pages, published by Harper & Brothers, New York City. Price, $1.50.

ACCORDING to the authors, the new public speaker is primarily the speaker of the conference room. Such being the case, the object is not to develop a resounding orator of the Fourth of July type, but to produce speakers that can meet the give-and-take conditions of coöperative discussion such as now prevail in the conference rooms of many lines of business and professional endeavor. The conference-room speaker can win only by being orderly, well informed, convincing, and—most of all—sincere, in other words, quite the opposite from the generally conceived notion of the public speaker.